APPENDIX I

TECHNICAL MEMORANDUM

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Memorandum

To: WMG&CP Group

From: Harry Debye, Jim Langseth, Colin Brownlow, and Julie Sullivan

Subject: Revised Soil Cleanup Levels

Date: December 5, 2003

Project: 13/49-015 JSL 006

Executive Summary

This Technical Memorandum has been prepared for the purpose of: (1) updating the soil cleanup levels for the Waukegan Manufactured Gas and Coke Plant (WMG&CP) Site (Site); and (2) evaluating additional soil management options protective of mixed use redevelopment that could include future residential land use at the Site.

The updated soil cleanup levels are summarized in Table 1. Two cleanup levels changed as a result of the evaluations presented in this memorandum: the naphthalene cleanup level was lowered from 48,556 mg/kg to 2,240 mg/kg and the arsenic cleanup level was lowered from 940 mg/kg to 639 mg/kg. All other cleanup levels are unchanged, and in fact were found to be more protective than previously estimated.

The analysis presented in this memorandum, using current risk factors, shows that the revised ROD cleanup levels incorporated herein, when combined with reasonable soil management options, are protective for residential development as part of a mixed use redevelopment of the site. The soil management options include: (1) reliable, effective vapor intrusion controls as part of building construction standards; (2) the placement of at least 3 feet of clean fill on top of areas of the Site where the redevelopment does not include buildings or other direct exposure barriers; and (3) adherence to the provisions of the Soil Management Plan including groundwater use prohibitions and management of excavated soil.

1.0 Introduction

This Technical Memorandum has been prepared to: (1) update the soil cleanup levels for the Site; and (2) provide the risk analytical basis to evaluate alternative future mixed use redevelopment options for the Site, including residential land use. This Technical Memorandum is based on the Record of Decision (ROD) soil cleanup level development presented in the Feasibility Study (FS) for the Site (Barr, 1998). The City of Waukegan acquired the WMG&CP property after issuance of the ROD. The City has indicated a desire to be able to pursue mixed use redevelopment of the property. Based on discussions with the City, the future mixed use redevelopment scenarios considered herein assume that a minimum of 3 feet of clean fill will be placed on top of areas of the Site where no buildings or other direct soil exposure barriers are constructed and where residual impacts may remain after completion of the soil remedial action, and that residential construction standards will include vapor intrusion control systems of a minimum 95 percent control efficiency.

The revised soil cleanup levels account for adjustments in toxicity information and risk calculation procedures since the time of preparation of the FS. These adjustments are primarily related to the availability of an inhalation toxicity value for naphthalene, and a noncarcinogenic reference value for arsenic but other adjustments are also made, including an updated cancer slope factor for polychlorinated biphenyls (PCBs) and updated toxicity values for naphthalene and dibenzofuran. This Technical Memorandum evaluates naphthalene and benzene volatilization from the soil and groundwater, for both indoor and outdoor exposure scenarios. The methodology used in this update is based on state-of-the art science, policy and procedures defined in the United States Environmental Protection Agency (U.S. EPA) exposure and risk assessment guidelines and recommendations of expert Federal panels.

This Technical Memorandum summarizes the overall approach to developing target soil concentrations and presents the updated cleanup level evaluation for commercial/industrial land use. This Technical Memorandum also evaluates additional soil management options to support potential mixed redevelopment involving residential as well as commercial, recreational, and other compatible land uses. The Site owner or future developers will be able to use that evaluation as a basis to define development options that will preclude unacceptable risk exposure and to define the required administrative steps to obtain approval for alternative site redevelopment options.

2.0 Target Soil Concentration Development Approach

Target Soil Concentrations (TSCs) were developed using models identical to those used in standard U.S. EPA risk assessments. However, with the TSC approach, an acceptable level of risk was predetermined, and the corresponding acceptable target concentrations of the chemicals of concern (COCs) were calculated for site-specific exposure scenarios. The risk levels presented are representative high exposure (RHE) scenarios. These were the basis for the ROD soil cleanup levels. The risk levels are set at an excess cancer risk of 10^{-5} for carcinogens for commercial/industrial and construction/utility scenarios, 10^{-6} for carcinogens for the recreational-child scenario, and a hazard Index (HI) of 1 for noncarcinogens.

The overall approach used in the development of risk-based cleanup goals consisted of the following steps:

1. Definition of future site use
2. Selection of COCs
3. Definition of exposure conditions
4. Toxicity assessment
5. Development of target concentrations for soil cleanup

The calculated TSCs for each exposure scenario are summarized in Table 2.

2.1 Guidance Documents

The TSCs for protection of human health were derived through use of standard risk equations and default assumptions or a combination of default and site-specific assumptions as presented in the following U.S. EPA guidance documents:

- *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual Part A, 1989*
- *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual Part B, Development of Risk-Based Preliminary Remediation Goals, 1991*
- *Soil Screening Guidance: Technical Background Document, 1996*
- *Exposure Factors Handbook, 1989, 1997*
- *Dermal Exposure Assessment: Principles and Applications, 1992*
- *Soil Screening Guidance for Chemicals, Calculation Tools, 2003*
- *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings, 2003*

3.0 ROD Remedy Land Uses

This section updates the soil cleanup standards that were selected in the ROD, and were originally calculated in Appendix 3-B of the FS. FS Appendix 3-B is reproduced in Appendix A of this Memorandum for convenient reference. For those scenarios used to calculate ROD soil cleanup levels, the exposure assumptions for the original exposure scenarios are unchanged; the only adjustments are for updated toxicity information. For those scenarios that were not available from Appendix 3-B of the FS, new site-specific exposure assumptions are developed consistent with those used for the ROD soil cleanup levels. Indoor vapor inhalation and recreational scenarios have also been added, for which new exposure assumptions were added.

3.1 COCs

The ROD selected the primary COCs in soil for the site: carcinogenic polynuclear aromatic hydrocarbons (cPAHs), arsenic, dibenzofuran, 4-methylphenol, and naphthalene. The TSC calculations also consider the COCs identified in the Human Health Risk Assessment (HHRA, U.S. EPA, 1995a) completed for this site: PCBs and benzene.

3.2 Exposure Conditions

TSCs are developed based on the extent to which an individual would be likely to come into contact with the COCs detected in soils (i.e., the potential for exposure). The exposure assumptions used to develop TSCs for the site were formulated through consideration of the site future land use, potential human receptors, potentially complete exposure pathways, and exposure routes.

Considerable judgment is involved in the development of exposure conditions. In developing the TSCs, conditions representing a high level of exposure to COCs at the redeveloped site were selected, designated "representative high exposure" (RHE). The significant distinctions between RHE exposure conditions and commonly used exposure conditions for development of preliminary remediation goals (PRGs) are highlighted in the following paragraphs. Each of these exposure scenarios includes a combination of default U.S. EPA values for risk assessment as well as site-specific values.

3.3 Exposure Pathways

An exposure pathway consists of a contaminated source (e.g., soil), a point of potential contact for humans with the contaminated source, and an exposure route (e.g., ingestion of contaminated soil). The following paragraphs describe applicable pathways and site-specific conditions.

Soil Pathway. Based on commercial/industrial future land use, the potential for direct human contact with site soils was assumed to be a viable exposure pathway. It was assumed that the potential human receptors may ingest or come in contact with soils as a result of the following activities:

1. Exposure of construction/utility workers to surface and subsurface (upper 5 feet) soils.
2. Occupational exposure to surface soils at the redeveloped site during normal commercial/industrial land-use activities.

The ROD remedy provides for removal of soil with a 1×10^{-5} or higher excess cancer risk or HI greater than 1. Soil with an excess cancer risk between 1×10^{-5} and 1×10^{-6} is to be covered with a 6-inch soil cover, buildings, parking surfaces, or other direct-contact barriers.

The ROD remedy is also consistent with recreational land use for the site. For recreational land use, it is assumed that 6 inches of soil cover would be placed over the entire site. Consequently, recreational users are not subject to direct contact exposures, but the vapor inhalation pathway must still be considered. Table 3 is a summary of the soil cover program according to land use.

Air Pathway – Contaminants in surface soils could be released to the ambient air through volatilization and wind-driven erosion or mechanical suspension. Contaminants in subsurface vadose zone soils could be released to the ambient air through volatilization. The significance of the ambient air inhalation pathway depends on site conditions such as the human behavior patterns, the physical and chemical characteristics of the contaminants, the degree of soil disturbance, the soil chemical concentrations, meteorological conditions, soil moisture, and related soil properties. Reference concentrations for chronic exposure to naphthalene vapors have become available since the time the FS was in preparation. Consequently, this Technical Memorandum includes evaluation of the air pathway in developing the TSCs for the construction/utility, the commercial/industrial scenarios, and the recreational-child scenario. The commercial/industrial evaluation also considers volatilization of naphthalene and benzene from the soil or groundwater to indoor air space.

3.4 Exposure Routes

An exposure route is how a particular COC connects to a receptor. In the development of TSCs, it was assumed that construction/utility and commercial/industrial workers could be exposed to COCs in soil by two primary exposure routes: incidental soil ingestion, and inhalation of particulates and volatiles released from soils. While exposure through dermal contact is also possible, this exposure route was not quantitatively evaluated due to the lack of dermal toxicity values. The absorption of chemicals from soil depends on chemical-specific factors as well as the characteristics of the soil. For chemicals exhibiting percentage absorption from soils less than 10%, (such as the COCs for this site) the dermal pathway is not expected to be significant in comparison to the soil ingestion and inhalation exposure pathways. For the recreational-child scenario, it was assumed that a child playing outdoors could be exposed to COCs by inhalation of volatiles released from soils.

For this evaluation, the TSCs based on the soil ingestion and/or inhalation exposure routes (whichever is lower) are considered protective for the dermal exposure route as well. In the HHRA, the dermal exposure was assumed to be equivalent to exposure from ingestion in accordance with IEPA guidance at that time. This approach may have resulted in an overestimation of risk. It should be noted that the dermal exposure route is not included in the U.S. EPA *Soil Screening Guidance for Chemicals* (U.S. EPA, 2003a) calculation model. In developing the PRGs in the HHRA, the U.S. EPA used the same exposure routes for all COCs except for cPAHs and PCBs. For these compounds, the HHRA did not consider inhalation exposure due to a lack of inhalation toxicity values. In developing the TSCs, inhalation and ingestion of these contaminants is treated in the same manner as in the HHRA. The specifics of the exposure scenarios are summarized below and in Table 4.

3.5 Exposure Scenarios

1. **Construction/Utility Worker**

   This site-specific exposure scenario is from FS Appendix 3-B (attached as Appendix A to this memorandum) and was used in development of the soil cleanup levels adopted in the ROD. It was assumed that a construction worker would be exposed to the upper 5 feet of contaminated soil (the entire depth of the vadose zone) over an exposure domain of approximately 2 to 5 acres. This corresponds to construction of a foundation for a structure the size of OMC's Plant No. 1 south of the Site. An exposure frequency of 30 days was considered representative of the duration a given worker might be constructing foundations for such a building. For the utility worker exposure scenario, it was assumed that a utility worker would be exposed to the upper

5 feet of contaminated soil over an exposure domain of approximately 2 acres. This corresponds to one utility construction crew building three utility lines (storm sewer, sanitary sewer, and water) along the entire north-south dimension of the site. An exposure frequency of 30 days to perform the work was considered a reasonable estimate. To obtain an RHE, the exposure frequency was considered to be 60 days for the construction or utility worker, based on the above estimates, and an allowance of a factor of 2 for uncertainty in work efficiency. A soil ingestion rate of 200 mg/day was used for calculation of the risk associated with the ingestion pathway, and is considered a high ingestion rate based on the nature of most utility and foundation construction work. In addition to exposure via ingestion, there is the potential for inhalation exposure from dust and volatile compounds, which was also evaluated for the construction/utility worker scenario.

2. **Commercial/Industrial Worker**

This site-specific exposure scenario is from FS Appendix 3-B (attached as Appendix A to this memorandum) and was used in development of the soil cleanup levels adopted in the ROD. To develop a basis for potential occupational exposure under the commercial/industrial scenario, it was assumed that the exposure domain would be on the order of 5 acres. For the RHE scenario, it was assumed that workers may be outdoors for lunch or other activities for 97.5 days/year (the estimated number of decent weather, non-vacation days per year) over a 25-year period. The exposure pathways evaluated for the commercial/industrial worker scenario were inhalation exposures from dust and volatile compounds and exposure via ingestion (see Appendix B). Incidental ingestion was assumed to be 2 milligrams of contaminated soil per day to reflect the time spent outdoors in proportion to time spent indoors. The RHE exposure scenarios represent a high level of exposure, considering likely site-specific future conditions. For most compounds, the exposure conditions which have the greatest sensitivity with regard to future risk are the assumed ingestion rate, exposure frequency and the volatilization of contaminants. The ingestion rate of 2 mg/day and the exposure duration of 97.5 days/yr represent upper bound values for future exposure scenarios when considering the likely outdoor activities for future industrial/commercial workers and the likely limited exposure to bare soil surfaces. The ROD remedy provides for removal of the soil that exceeds a 1×10^{-5} excess cancer risk or hazard index of 1 under this scenario. Soil between 1×10^{-5} and 1×10^{-6} excess cancer risk is covered with 6 inches of soil and vegetation, gravel, asphalt or concrete and buildings in accordance with the ROD remedy. Consequently, the ROD remedy, including soil cover would, for practical purposes, preclude the exposure pathway and be much more protective than indicated by the soil cleanup levels used to define soil removal. Most new industrial/commercial facilities incorporate significant pavement and landscaping, and most commercial/industrial workers spend the majority of the working day indoors. Realistically, after the ROD remedy, and certainly after redevelopment, it is likely that there will be no opportunity for these workers to contact subsurface soils.

In addition to outdoor exposure, there is the potential for inhalation exposure to volatile compounds (i.e., naphthalene and benzene) that may enter the building through cracks in the foundation. The indoor exposure evaluation was performed in order to assess the concentration of naphthalene or benzene in the soil or groundwater that would be protective in the absence of building vapor control measures. The evaluation used the Johnson and Ettinger Soil Vapor Intrusion Model, and incorporates default values as needed from the document User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings (U.S. EPA, 2003b). Some of the key inputs are site-specific values – where default values may be inappropriate. The modeling assumed the ROD remedy 6-inch soil cover was present, except below the slab-on-grade construction as shown on Figure 1. The 6-inch cover matches the slab thickness assumed in the model, so in order to maintain internal consistency in the model, the 6-inch cover was assumed to be the same soil as the current vadose zone at the site. In actual practice, the cover soil can be whatever is most suitable for redevelopment. Figure 1 shows the soil profile and soil parameters used in the model. There was no reasonable high exposure scenario developed for this exposure route at the time of FS preparation. The RHE conditions for this scenario assumed that a given commercial/industrial worker would be exposed for an average of 25 years for 219 days per year. The basis for this scenario is developed in greater detail in Appendix B. This RHE scenario is a higher exposure level than would be used for seasonal marine commercial activity such as that typical of the existing Larsen Marine business. Appendix B also includes copies of the spreadsheets that were used in the modeling.

The building ventilation parameters used in the modeling were those recommended for standard construction. The air in commercial space was assumed to exchange 1.5 times per hour, which is based on the ASHRAE 62-1999 (ASHRAE is the American Society of Heating Refrigerating and Air-Conditioning Engineers) standard for commercial office space, assuming 12-foot ceilings. The values used in the model are consistent with new construction. No vapor barrier was assumed in this modeling. Note that space with less ventilation than assumed may compensate with addition of vapor control.

The Johnson and Ettinger model uses an inherently conservative approach to estimating indoor air concentration of vapors. The model assumes the entire area under the building is at the estimated concentration of the compound. The vapor intrusion to the building assumes soil vapor can readily enter the building, predominantly through cracks along the foundation perimeter. The model is designed to be reliably conservative, and has been structured and designed to over-predict indoor concentrations as compared to actual conditions.

3. Recreational - Child

For this scenario, which was not considered in FS Appendix 3B, it was assumed that a child would be playing outdoors in a "sandbox" all day 20 days per year over a 6-year period. The TSCs developed (see Table 2) based on this exposure scenario are expected to be protective for recreational use of the site where activities such as walking or picnicking could occur, as these involve less intense exposure. An exposure frequency of 20 days was considered representative of the number of times a given child might be playing in the area. The only potential exposure pathway for the recreational-child exposure scenario would be the inhalation pathway. A child would not be exposed to the COCs via direct contact with the soil, ingestion of the soil, or inhalation of fugitive dust because the site will be covered (soil and vegetation, gravel, asphalt or concrete and buildings), thus limiting exposure. The details of the modeling of this scenario are in Appendix B.

3.6 Toxicity Assessment

The chemical concentration in soil that is considered safe depends, in part, on the inherent chemical toxicity. The toxic effect of a chemical also depends on the dose or concentration of the substance to which an individual is exposed. Toxicity values describe the quantitative dose-response relationship between the chemical dose to which a receptor is exposed and the incidence of adverse health effects. The toxicity value for a chemical may differ depending on the route by which a receptor is exposed (i.e., by ingestion, inhalation). Due to the lack of toxicity values for dermal exposure, this exposure route could not be quantitatively evaluated. It should be noted that the dermal exposure route is not included in the U.S. EPA *Soil Screening Guidance for Chemicals* (U.S. EPA, 2003a) calculation model as explained in Section 3.4. The use of dose-response data from oral exposure for a specific chemical to predict effects from exposure to that chemical via dermal exposure (as was done in the HHRA, U.S. EPA, 1995) is not supported by scientific evidence. Consequently, using the oral slope factor to evaluate the risk associated with dermal exposure to PAHs, which cause skin cancer through direct action at the point of application, is not appropriate. For the cPAHs at this Site, the dermal exposure route is likely to be a much less significant contributor to risk than the ingestion exposure route. The lowest concentration among the various pathways was selected as the cleanup level for the site. Consequently, the absence of quantitative evaluation of the dermal pathway introduces only a very small level of uncertainty in the cleanup level determination process.

3.6.1 Cancer Risk

The dose-response relationship for carcinogens is expressed as a cancer slope factor or unit risk factor. Generally, the slope factor is a plausible upper-bound estimate of the probability of a response-per-unit intake of a chemical over a lifetime. The slope factor is usually, but not always, the upper 95th percentile confidence limit of the slope of the dose-response curve and is expressed as the probability of a response per milligram of chemical per kilogram of body weight per day $(mg/kg\text{-}day)^{-1}$. In risk assessment, the slope factor is used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a carcinogen. A unit risk factor is analogous to the slope factor but is expressed in units of $(\mu g/m^3)^{-1}$.

3.6.2 Noncancer Risk

The dose-response relationship for noncarcinogens is expressed for ingestion as a reference dose (RfD) in milligrams of chemical per kilogram of body weight per day (mg/kg-day) or for inhalation as a reference concentration (RfC) expressed in milligrams per cubic meter of air (mg/m^3). The reference dose (reference concentration) represents the concentration of a contaminant that is likely to be without an appreciable risk of adverse health effects during a lifetime daily exposure. In risk assessment the RfD (RfC) is used to estimate the potential for adverse health effects due to exposure to contaminants in soil or air.

Toxicity values derived by U.S. EPA for noncancer effects were used to develop the TSCs. This update uses the reference concentration (RfC) for naphthalene published by U.S. EPA in IRIS. This reference concentration is appropriate for chronic exposures (i.e., longer than 7 years) only, so use of this value for shorter duration exposures (utility worker) is highly conservative. The RfC developed by the U.S. EPA was based on studies conducted with laboratory mice because adequate human data were not available.

There is an extensive database showing that mice are more sensitive than humans and other primates (as well as more sensitive than rats, the other common laboratory test animal) to the effect of naphthalene on the respiratory tract. Because of the deficiencies in the database for naphthalene, the U.S. EPA lowered the RfC by an extra factor of 3 (that is, rather than the typical uncertainty factor of 1000, an uncertainty factor of 3000 was applied for naphthalene, indicating a high level of imprecision in the toxicity value). The California Reference Exposure Level (REL = 0.009 mg/m^3, CalEPA/OEHHA, 2003) and the ATSDR Minimal Risk Level (MRL = 0.010 mg/m^3, ATSDR, 1995) for naphthalene, which are the equivalent of the IRIS value, are 3 or more times higher than the IRIS Reference Concentration (0.003 mg/m^3). Broadly, this means that the inhalation-based naphthalene TSCs presented here are likely 3 or more times lower than may be justified by the available toxicological information about naphthalene.

3.7 Development of TSCs

The acceptable risk level for cancer and noncancer effects to determine site cleanup goals is primarily a policy decision by the risk manager. A cancer target risk value of one-excess-cancer-in-one-hundred-thousand (10^{-5}) over background risk level was selected by U.S. EPA in the ROD for the cancer endpoint for soil removal, and is used here in the development of the RHE TSCs. The recreational scenario uses a one-in-one-million (10^{-6}) excess cancer risk. For noncancer effects a hazard index of 1 was used (HI = 1) for all scenarios.

To calculate the acceptable soil concentration for the inhalation pathway, a particulate emission factor (PEF) and volatilization factor (VF) were derived based on guidance provided in U.S. EPA's Risk Assessment Guidance for Superfund, Part B (U.S. EPA, 1991) and Soil Screening Guidance document (U.S. EPA, 1996).

To calculate the TSCs, the exposure conditions are combined with the toxicity/cancer risk data for each of the COCs. Using these exposure values and the chemical-specific toxicity/cancer risk values, the target soil concentrations were calculated. Appendix B presents the calculation of the target soil concentrations for protection of human health. The resulting TSCs for the various exposure pathways are summarized in Table 5. The lowest TSC for each exposure scenario was selected as the cleanup level. The cleanup levels are summarized in Table 1. The cleanup levels for cPAHs increased as compared to the ROD levels. No adjustment of the ROD levels is proposed as a result of these updated TSC calculations. However, these results do show that the ROD cleanup levels for cPAHs are more protective than the nominal threshold of 10^{-5}. The arsenic cleanup level decreased to 639 mg/kg, the value shown for the ingestion pathway, noncarcinogenic, for the construction/utility scenario. The naphthalene cleanup level decreases to 2,240 mg/kg, the value shown on Table 5 for the commercial/industrial vapor intrusion exposure scenario. The naphthalene cleanup level is greater than the nominal soil saturation level for naphthalene. At the site, naphthalene is a separate component solid at ambient temperatures (melting point 80°C), or is present as a component of coal tar. The U.S. EPA Region 9 memorandum describing use of their Preliminary Remediation Goals (PRGs) (U.S. EPA, 2002) explains that for substances that exceed the soil saturation limit and are solids, the PRG should not be calculated based on the inhalation pathway. The Soil Screening Guidance (U.S. EPA, 1996) suggests the cleanup level for such chemicals should be based on protection of other exposure pathways in such cases. In view of the much higher cleanup levels that are calculated for naphthalene based on the other pathways, the conservatism associated with using this vapor intrusion calculation approach was accepted for selection of the site-specific naphthalene cleanup level.

A cancer target risk value of one excess cancer-in-one-million (10^{-6}) over background risk level was selected for the cancer endpoint in the development of the recreational-child TSCs. For noncancer effects a HI of 1 was used. The naphthalene TSC for the recreational-child scenario is 24,000 mg/kg, as shown in Tables 2 and 5. This is a higher standard than the commercial/industrial naphthalene TSC. Consequently the ROD cleanup, with the revised 2,240 mg/kg naphthalene cleanup value is also protective of the recreational scenario. Similarly, the Table 2 benzene TSC for the recreational-child scenario is 540 mg/kg, which is a higher value than the commercial/industrial TSC of 5.5 mg/kg, and higher than any reported vadose zone soil concentration of benzene at the Site. Consequently, the ROD cleanup is also protective of the recreational scenario.

The volatilization from groundwater model results are included in Appendix B. There is no reason to expect an indoor air problem from groundwater. The highest reported shallow groundwater sample naphthalene concentration at the Site was 2,400 µg/L, which is much less than the acceptable concentrations derived from commercial/industrial vapor intrusion model (79,700 µg/L, a value which exceeds the 31,200 µg/L solubility of naphthalene). The highest reported shallow groundwater sample benzene concentration at the Site was 70 µg/L, which is much less than the acceptable concentrations derived from commercial/industrial vapor intrusion model (4,930 µg/L).

The vaporization from soil model shows that for commercial/industrial space, there is no reason to expect an indoor air problem with respect to naphthalene. The revised soil naphthalene cleanup standard of

2,240 mg/kg is protective of workers, without a vapor intrusion control system. It assumes the standard office space ventilation of 1.5 air exchanges per hour. Including a vapor intrusion control system requirement in commercial/industrial building standards for Site redevelopment such as those required for residential redevelopment would lower potential worker exposure further and would accommodate lower building air exchange rates. The modeled benzene concentration of 5.5 mg/kg is shown in Tables 2 and 5 and Appendix B, and is the lowest of the benzene concentrations protective of construction/utility and commercial/industrial workers. This protective concentration assumes no vapor intrusion control system. Benzene concentrations of interest at the Site are found in association with tar, and the tar cleanup levels are much more rigorous than this benzene value. Consequently, no separate benzene cleanup level is proposed for the site remedy.

4.0 Mixed Use Development

This portion of the Technical Memorandum evaluates additional soil management options for potential mixed use redevelopment involving residential as well as commercial, recreational, and other compatible land uses. TSCs protective of commercial/industrial and recreational land use scenarios were developed above. This section evaluates additional soil management options to support the development of mixed use redevelopment plans that could include potential future residential land use at the property. As noted below, the revised ROD cleanup standards incorporated herein when combined with vapor intrusion controls as part of building construction standards and the placement of at least 3 feet of clean fill on top of areas of the Site where the redevelopment does not include buildings or other direct exposure barriers, and where residual impacts may remain after completion of the soil remedial action, will allow residential as well as commercial and recreational redevelopment based on current risk factors. These provisions will be identified in the Soil Management Plan (SMP) to be developed for the site.

The SMP will enumerate other requirements for redevelopment of the site as well. These include a groundwater use prohibition, a program for management of excavated soil, soil sample data that can be used for development of OSHA worker "right-to-know" information, as necessary, and other information and guidance to accommodate work at the site or changes to the land use at the site.

Among the additional soil management options available to support potential residential development at this former industrial property, there are two that directly affect the risk evaluation: (1) placement of at least 3 feet of clean soil cover over the areas of the Site where the redevelopment does not include buildings or other direct soil exposure barriers (e.g., paved surfaces, landscaping above current grade, sidewalks, and other amenities) and where residual impacts may remain after completion of the soil remedial action; and (2) installation of vapor control systems when buildings are constructed. These requirements are consistent with City expectations. The City of Waukegan has stated, in their August 21, 2003 Technical Memorandum "Revised Risk Assessment Evaluation," that engineering controls such as installing vapor control systems on future buildings can be used to eliminate the indoor vapor intrusion pathway. The City document also called for a minimum of 36 inches of clean soil cover to be added to areas that will not be subject to other exposure controls.

The addition of 3 feet of clean cover soil eliminates any credible exposure pathway for routine oral or dermal contact with any residual soil contamination. The installation of vapor control systems on buildings provides a system for addressing any future vapor intrusion issues.

4.1 COCs and Toxicity Assessment

The COCs for the Site were identified above for the commercial/industrial and recreational scenarios, and apply to the residential scenario as well. The toxicity assessment summarized above for the commercial/industrial and recreational scenarios also covers the matters relevant to the residential scenario.

4.2 Exposure

Most of the site will be covered (soil and vegetation, gravel, asphalt or concrete and buildings), thus limiting exposure to only inhalation of chemicals in air due to volatilization. The recreational scenario presented earlier provides confidence that the ROD remedy, with the naphthalene adjustment proposed in this Technical Memorandum, is protective for outdoor recreational and residential activities.

Indoor Air Exposure –The indoor exposure evaluation was performed in order to assess the concentration of naphthalene or benzene in soil or groundwater that would be protective, assuming building vapor control measures as called for in the City's Revised Risk Assessment Evaluation. The evaluation here is based on vapor controls that are 95 percent efficient (i.e., intercept or block 95 percent of the subsurface vapor from entering the indoor air space). The soil and groundwater concentrations were developed by applying this 95 percent efficiency to the concentrations from the Johnson and Ettinger Soil Vapor Intrusion Models in Appendix C. The models incorporate default values as needed from the User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings and site specific values where default values may be inappropriate.

The model default values assume a one story structure with approximately 1,000 square feet of living space, occupied continuously 350 days per year. This is not consistent with new urban development. Accordingly, the exposure assumptions were adjusted to reflect at least a modest amount of time spent away from the residence, whether at work, running errands, vacationing, or for other activities. The exposure frequency was set at 208 days per year, with an exposure duration of 9 years. The basis for this scenario is developed in greater detail in Appendix C. No correction was applied to account for multi-story buildings typical of new urban development. The building ventilation parameters used in the modeling were those recommended in ASHRAE 62-1999 for residential construction: the air in residential structures was assumed to exchange 0.35 times per hour (rather than the default value of 0.25 exchanges per hour).

The modeling (see Appendix C) assumed the ROD remedy 6-inch soil cover immediately adjacent to the building and slab-on-grade construction. The 6-inch cover matches the slab thickness assumed in the model, so in order to maintain internal consistency in the model, the 6-inch cover was assumed to be the same soil as the current vadose zone at the site. In actual practice, the cover soil may be whatever soil types are most suitable for redevelopment, and would be a more protective 3-feet thick rather than 6 inches thick. Figure 1 shows the soil profile and soil parameters used in the model.

4.3 Development of TSCs

The vapor intrusion to indoor air pathway was considered for both vaporization from groundwater and from soil. The model of vapor intrusion from soil for residential space, with a 95 percent efficient vapor control system in place, shows that the revised ROD soil cleanup levels (Table 1) are protective.

The model result for vapor intrusion from soil for benzene, with a 95 percent efficient vapor control system, is 2.4 mg/kg as shown in Table 5. This concentration exceeds any Site vadose zone soil benzene concentration reported outside the ROD remedy soil removal area.

The vaporization from groundwater model, also applying the 95 percent efficient vapor control system, shows that naphthalene is not a parameter of concern for residential land use. The modeled groundwater concentration exceeds the solubility of naphthalene. This was the case even in the absence of supplementary vapor control systems.

The vaporization from groundwater model for benzene also shows that a 95 percent efficient vapor control system is protective for residential buildings. The highest reported shallow groundwater sample benzene concentration at the Site (70 μg/L) was less than the Table 5 concentration derived from the residential vapor intrusion model (12,000 μg/L). The model shows that the shallow groundwater benzene concentrations at the Site would not be a problem even in the absence of supplementary vapor control systems.

The vapor intrusion modeling has implicit averaging over a domain equal to the size of the structure. In fact, the site soil cleanup levels are maximums, so the actual average residual concentrations in the soil will be lower than the cleanup levels. Thus, measures to provide protection at the stated level will actually afford a margin of security beyond the nominal protective level.

The conclusion of this review of the potential for mixed use redevelopment of the site is that the ROD cleanup levels are protective, with naphthalene meeting the revised cleanup levels suggested in this Technical Memorandum, and incorporating the City's requirements for buildings of a vapor control system that is reliably 95 percent efficient, and where there will be no buildings or other exposure barriers, the addition of 3 feet of soil cover.

References

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Tables

Table 1

Revised Soil Cleanup Levels
Waukegan Manufactured Gas and Coke Plant Site
Waukegan, Illinois

Chemical	Soil Cleanup Level (mg/kg)
Arsenic[2]	**639**
Benzo(a)anthracene[1]	1,160
Benzo(a)pyrene[1]	116
Benzo(b)fluoranthene[1]	1,160
Dibenzo(a,h)anthracene[1]	116
Indeno(1,2,3-cd)pyrene[1]	1,160
Dibenzofuran[2]	5,390
4-Methylphenol[2]	6,738
Naphthalene[2]	**2,240**

[1] 1×10^{-5} excess cancer risk
[2] Non-cancer risk, hazard index = 1
Bold = new or revised

Table 2
Summary of Target Soil Concentrations for ROD Remedy Land Uses
Waukegan Manufactured Gas and Coke Plant Site
(concentrations in mg/kg)

Chemical	Recreational - Child [1]	Commercial/Industrial [2] RHE	Construction/Utility RHE
PCBs	1,600	760	43
Arsenic		2,450	639
Benzene	540	5.5	3,600
Benzo(a)pyrene		503	204
Benzo(a)anthracene		5,030	2,040
Benzo(b)fluoranthene		5,030	2,040
Dibenzo(a,h)anthracene		503	204
Indeno(g,h,i)pyrene		5,030	2,040
Naphthalene	24,000	2,240	7,900
4-Methylphenol		655,000	10,600
Dibenzofuran		524,000	8,520

[1] Only potentially exposed via inhalation of volatiles.

[2] Includes vapor intrusion to indoor air pathway.

Table 3

Soil Cover Programs for Acceptable Land Uses
Waukegan Manufactured Gas and Coke Plant Site

Land Use	Soil Cover Program	Risk Calculation Comments
Commercial/Industrial	0.5 ft. soil cover. No soil is required where buildings, paved surfaces, and other direct-contact barriers, or where less than $1x10^{-6}$ excess cancer risk and hazard index of 1 are present.	To add a greater degree of protection, the risk calculations ignore the soil cover for the inhalation and ingestion pathways and are, therefore, conservative.
Recreational	0.5 ft. soil cover minimum. If in combination with residential land use, 3 ft. soil cover. No soil cover is required where buildings, paved surfaces, and direct-contact barriers are present.	The soil cover is protective for direct contact, so only inhalation pathways are relevant.
Residential	3 ft. soil cover. No soil cover is required where buildings, paved surfaces, and direct-contact barriers are present.	The soil cover is protective for direct contact, so only inhalation pathways are relevant.

Table 4

Summary of Exposure Values
Waukegan Manufactured Gas and Coke Plant Site
Waukegan, Illinois

	RHE	Units	Source
All Exposure Scenarios			
Body Weight Adult	70	kg	U.S. EPA, 1989
Child	15	kg	
Averaging Time (AT_c), carcinogenic	70	years	U.S. EPA, 1989
Averaging Time (AT_{nc}), noncarcinogenic			AT_{nc} = Exposure Duration (ED)
Particulate Emission Factor		Calculated	Exposure scenario specific
Volatilization Factor (VF)		Calculated	Chemical and exposure scenario specific
Inhalation Rate (IR)	20	m^3/day	U.S. EPA, 1989
Construction/Utility Worker			
Carcinogenic Target Risk	10^{-5}		Site specific
Exposure Duration (ED)	1	year	Professional judgment
Exposure Frequency (EF)	60	days/year	
Soil Ingestion Rate (IR)	200	mg/day	U.S. EPA, 1996
Commercial/Industrial Work—Outdoors			
Carcinogenic Target Risk	10^{-5}		Site specific
Exposure Duration (ED)	25	years	U.S. EPA, 1997
Exposure Frequency (EF)	97.5	days/year	Professional judgment
Soil Ingestion Rate (IR)	2	mg/day	
Commercial/Industrial Worker—Vapor Intrusion			
Carcinogenic Target Risk	10^{-5}		Site specific
Exposure Duration (ED)	25	years	U.S. EPA, 1997
Exposure Frequency (EF)	219	days/year	U.S. EPA, 1993
Recreational—Child			
Carcinogenic Target Risk	10^{-6}		Site specific
Exposure Duration (ED)	6	years	U.S. EPA, 1995
Exposure Frequency (EF)	20	days/year	Professional judgment
Residential—Vapor Intrusion			
Carcinogenic Target Risk	10^{-6}		Site specific
Exposure Duration (ED)	9	years	U.S. EPA, 1989
Exposure Frequency (EF)	208	days/year	Professional judgment

Table 5
Pathway-Specific Target Soil and Groundwater Concentrations
Waukegan Manufactured Gas and Coke Plant Site
(concentrations in mg/kg)

Chemical	Recreational - Child [1]	Commercial/Industrial RHE				Construction/Utility RHE			
	Inhalation	Ingestion		Inhalation		Ingestion		Inhalation	
	Volatiles	Carcinogenic	Noncarcinogenic	Dust	Volatiles	Carcinogenic	Noncarcinogenic	Dust	Volatiles
PCBs	1,600	1,830	2,620	284,000	760	745	43	11,600,000	31,000
Arsenic		2,450	39,300	37,800		994	639	1,540,000	
Benzene	540	66,700	524,000	20,800,000	260	27,100	8,520	283,000,000	3,600
Benzo(a)pyrene		503				204			
Benzo(a)anthracene		5,030				2,040			
Benzo(b)fluoranthene		5,030				2,040			
Dibenzo(a,h)anthracene		503				204			
Indeno(g,h,i)pyrene		5,030				2,040			
Naphthalene	24,000		2,620,000	17,400,000	4,900		42,600	28,300,000	7,900
4-Methylphenol			655,000				10,600		
Dibenzofuran			524,000				8,520		

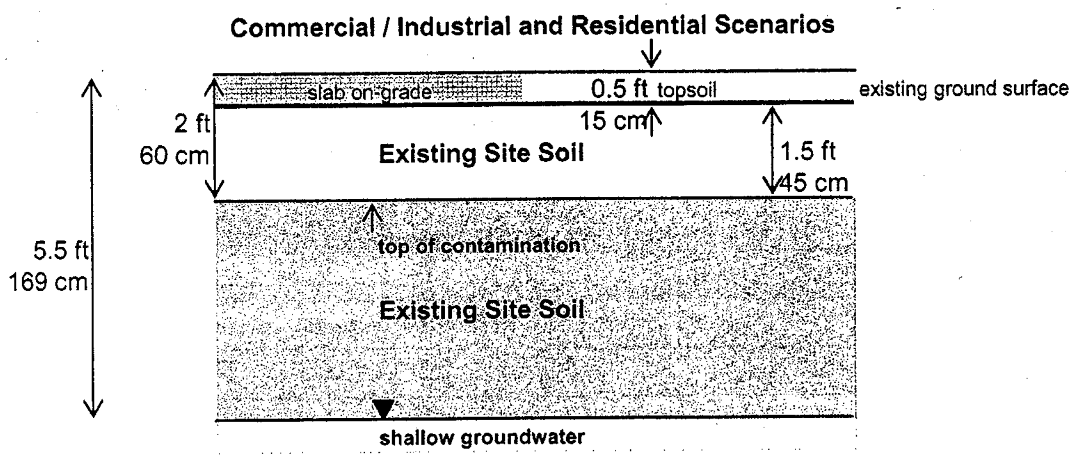
[1] Only potentially exposed via inhalation of volatiles.

A value greater than 1,000,000 parts per million shows the exposure is not of concern.

Chemical	Vapor Intrusion	
	Residential [2]	Commercial/ Industrial
Benzene - Soil (mg/kg)	2.4	5.52
Benzene - Groundwater (mg/L)	12.0	4.93
Naphthalene - Soil (mg/kg)	2,820	2,240
Naphthalene - Groundwater (mg/L)	778	79.7

[2] with 95% efficient vapor control

Figures



Existing Site Soil*

parameter	value	unit	
ρ_b	1.67	g/cm^3	RI Appendix 4-K, computed from geotechnical laboratory reports
η^v	0.39	cm^3/cm^3	RI Table 4.6-3
Θ_w^v	0.26	cm^3/cm^3	RI Appendix 4-C, computed from representative samples
f_{oc}	0.02	g/g	RI Table 4.6-2

* existing site soil parameters were used for the 0.5 ft ROD remedy topsoil cover for the internal consistency of the Johnson and Ettinger Model

Figure 1
Vapor Intrusion Model: Soil Parameters
Waukegan Manufactured Gas and Coke Plant Site

Appendix A
Feasibility Study Appendix 3B

Appendix 3-B

Development of Target Soil Concentrations Protection of Human Health

List of Tables

Appendix 3-B

Development of Target Soil Concentrations
Protection of Human Health

The target soil concentrations (TSC) for protection of human health were derived through use of standard risk equations and default assumptions or a combination of default and site-specific assumptions as presented in the following EPA guidance documents:

- *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual Part A, 1989*
- *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual Part B, Development of Risk-Based Preliminary Remediation Goals, 1991*
- *Soil Screening Guidance: Technical Background Document, 1996*
- *Exposure Factors Handbook, 1989, 1996*
- *Dermal Exposure Assessment: Principles and Applications, 1992*

TSC Approach

TSCs were developed using models identical to those used in standard EPA risk assessments. However, with the TSC approach, an acceptable level of risk (i.e., 10^{-4}, 10^{-5}, 10^{-6}) was predetermined, and the corresponding acceptable target concentrations of the chemicals of concern were calculated for site-specific exposure scenarios for the site.

The overall approach used in the development of risk-based cleanup goals consisted of the following steps:

1. Selection of target chemicals
2. Definition of future site use
3. Definition of exposure conditions
4. Toxicity assessment
5. Development of target concentrations for the preliminary remediation goals

Target Chemicals

Based on the HHRA completed for this site, the primary contaminants of concern in soil were carcinogenic PAHs and arsenic (U.S. EPA, 1995a). The TSCs also consider the COCs identified for the site in the HHRA—PCBs, benzene, dibenzofuran, 4-methylphenol, and naphthalene.

Future Site Use

Future site use is considered to be industrial and/or commercial. A detailed assessment of future land use considerations is presented in Appendix 3-C.

Exposure Conditions

TSCs are developed based on the extent to which an individual would be likely to come into contact with the target chemicals detected in soils (i.e., the potential for exposure). The exposure assumptions used to develop TSCs for the site were formulated through consideration of the site future land use, potential human receptors, potentially complete exposure pathways, and exposure routes.

Considerable judgement is involved in the development of exposure conditions. In developing the PRGs in the HHRA, two sets of exposure conditions—reasonable maximum exposure (RME) and central tendency exposure (CTE)—were evaluated. In developing the TSCs, a new set of exposure conditions is used—representative high exposure (RHE). The significant distinctions between these exposure conditions are highlighted in the following paragraphs. Each of these exposure scenarios includes a combination of default EPA values for risk assessment as well as site-specific values.

Exposure Pathways

An exposure pathway consists of a contaminated source (i.e., soil), a point of potential contact for humans with the contaminated source, and an exposure route (i.e., ingestion of contaminated soil). The following paragraphs describe these pathways and site-specific conditions.

Soil Pathway—Based on the anticipated future land use, the potential for direct human contact with site soils was assumed to be a viable exposure pathway. It was assumed that the potential human receptors may ingest or come in contact with soils as a result of the following activities:

1. Exposure of construction/utility workers to surface and subsurface (upper 5 feet) soils.

2. Occupational exposure to surface soils at the redeveloped site during normal commercial/industrial land-use activities.

Air Pathway—Contaminants in surface soils could be released to the ambient air through wind-driven erosion or mechanical suspension. The significance of the ambient air inhalation pathway depends on site conditions such as the human behavior patterns, the degree of soil disturbance, the soil chemical concentrations, meteorological conditions, soil moisture, and related soil properties. The air pathway was included in developing the TSCs for the construction/utility and commercial/industrial land use activities.

Exposure Routes

In the development of TSCs, it was assumed that utility, construction, and commercial/industrial workers could be exposed to target chemicals in soil by three exposure routes: incidental soil ingestion, dermal contact with soils, and inhalation of particulates and volatiles released from soils. In developing the PRGs in the HHRA, the U.S. EPA used all three exposure routes for all chemicals of concern except for cPAHs and PCBs. For these compounds, the HHRA did not consider inhalation exposure due to a lack of inhalation toxicity values. In addition, the dermal exposure was assumed to be equivalent to exposure from ingestion in accordance with IEPA guidance. In developing the TSCs, inhalation is treated in the same manner as the PRG calculations. However, dermal contact exposure is considered separately from ingestion because new values for dermal exposure are available in accordance with U.S. EPA guidance (U.S. EPA, 1998). The specifics of the three exposure scenarios are summarized below and in Table 3-B-1.

- Utility Worker

  For the utility worker exposure scenario, it was assumed that a utility worker would be exposed to the upper 5 feet of contaminated soil (the entire depth of the vadose zone) over an exposure domain of approximately 2 acres. This corresponds to one utility construction crew building three utility lines—storm sewer, sanitary sewer, and water lines—along the entire north-south dimension of the site. The exposure frequency was considered to be from 8 to 15 days for the CTE and RME scenarios. For the RHE scenario, this was increased to 60 days based on an estimate of 30 days to perform the work, and an allowance of a factor of 2 for uncertainty in work efficiency. The soil ingestion rate of 216 to 480 mg/day for the CTE and RME exposure scenarios was reduced slightly to 200 mg/day for the RHE scenario based on the mechanized nature of most utility construction work. Finally, for dermal contact, the CTE and RME exposures used a skin area of from 5,000 to 5,800 cm^2 with an adherence factor ranging from 0.2 to 1.0 mg/cm^2. For the RHE exposure scenario, the value of 5,800 cm^2 of exposed skin was retained as this is representative of the hands, arms and head. However, the low value of 0.2 for adherence of soil to skin was used as this represents an upper bound for irrigation installers.

- Construction Worker

For the construction worker, it was assumed that a construction worker would be exposed to the upper 5 feet of contaminated soil over an exposure domain of approximately 2 to 5 acres. This corresponds to construction of a foundation for a structure the size of OMC's Plant No. 1 south of the site. The exposure frequency used was from 18 to 21 days for the CTE and RME scenarios. For RHE, the exposure frequency was increased to 30 days. Soil ingestion and adherence values for the construction worker scenario were considered equivalent to those used for the construction worker for RME, CTE, and RHE exposure scenarios.

- Commercial or Industrial Workers

To develop a basis for potential occupational exposure under the commercial/industrial scenario, it was assumed that the exposure domain would be on the order of 5 acres. However, most of the site will be covered (soil and vegetation, gravel, asphalt or concrete and buildings), thus limiting exposure. For the RME and CTE scenarios, the exposure frequency was assumed to be 165 days per year with the exposure duration varying from 9 to 25 years. For the RHE scenario, it was assumed that workers may be outdoors for lunch or other activities for 97.5 days/year (the estimated number of decent weather, non-vacation days per year) over a 25-year period. Incidental ingestion was assumed to be from 0.825 to 8.05 grams of contaminated soil per day for CTE and RME, but was reduced to 0.002 for RHE in order to reflect the time spent outdoors in proportion to the total. Similarly, the soil adherence factor ranged from 0.2 to 1.0 for CTE and RME, but was reduced to .043 for RHE. The significantly lower values for RHE were used because it better represents credible exposure values, as explained below. Realistically, after redevelopment it is likely that there will be no opportunity for these workers to contact subsurface soils.

As previously mentioned, the RME and CTE values are typical of conservative preliminary remediation goals, but may be overly conservative for evaluating potential remedial actions during a feasibility study. By comparison, the target soil concentrations calculated using the RHE exposure scenario represent appropriate level of risk for consideration of site-specific future conditions. For most compounds, the exposure conditions which have the greatest sensitivity with regard to future risk are the assumed ingestion rate, exposed skin area, the soil adherence factor, and the exposure frequency. For example, the relatively high ingestion rates considered in the RME and CTE scenarios for the utility/construction worker scenarios exceed the ingestion rate used in the RHE scenario of 200 mg/day. This value is based on an upper value for irrigation installers and is therefore more representative of a reasonable upper bound for ingestion by utility/ construction workers.

Similarly, the ingestion rate, exposed skin area, and exposure frequency for the reasonable high exposure scenario (2 mg/day, 840 cm^2, and 97.5 days/yr) represent upper bound values for future exposure scenarios when considering the limited extent of likely outdoor activities for future industrial/commercial workers and the likely limited exposure to bare soil surfaces. Most new industrial/commercial facilities incorporate significant pavement and landscaping, and most commercial/industrial workers spend the majority of the working day indoors. The soil adherence factor, 0.043 mg/cm^2, is based on soil adherence to the hands of greenhouse workers. Soil adherence factors of 0.2 mg/cm^2 and 1.0 mg/cm^2 correspond respectively to irrigation installers (hands only; arms, legs and face were 0.02 mg/cm^2 or less) and a factor between reed gatherers (hands) and the high-end amount for rugby players.

Toxicity Assessment

The chemical concentration in soil that is considered safe depends, in part, on the inherent chemical toxicity. The toxic effect of a chemical also depends on the dose or concentration of the substance to which an organism is exposed. Toxicity values describe the quantitative dose-response relationship between the chemical dose to which an organism is exposed and the incidence of adverse health effects. The toxicity value for a chemical may differ depending on the route by which an organism is exposed (i.e., by ingestion, inhalation or through dermal contact).

Cancer Risk

The dose-response relationship for carcinogens is expressed as a cancer slope factor or unit risk factor. Generally, the slope factor is a plausible upper-bound estimate of the probability of a response-per-unit intake of a chemical over a lifetime. The slope factor is usually, but not always, the upper 95th percent confidence limit of the slope of the dose-response curve and is expressed as the probability of a response per milligram of chemical per kilogram of body weight per day $(mg/kg\text{-}day)^{-1}$. In risk assessment, the slope factor is used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a carcinogen. A unit risk factor is analogous to the slope factor but is expressed in units of $(\mu g/m^3)^{-1}$.

Toxicity values derived by EPA for carcinogenic effects were used to develop the TSCs.

Development of TSCs

The acceptable risk levels for cancer and noncancer effects to determine site cleanup goals is a policy decision, not a risk-based decision. The State of Illinois guidance provides a cancer target risk value of one excess cancer-in-one-hundred-thousand (10^{-5}) over background risk level for the cancer endpoint. This risk criterion was used in the development of the TSCs.

To calculate the acceptable soil concentration for the inhalation pathway, a particulate emission factor (PEF) and volatilization factor (VF) were derived based on guidance provided in EPA's RAGS part B and Soil Screening Guidance document.

To calculate the PRGs, the exposure conditions are combined with the toxicity/cancer risk data for each of the chemicals of concern. The risk values for various soil exposure conditions are summarized in Table 3-B-2.

Using these exposure values and the chemical-specific toxicity/cancer risk values, the target soil concentrations were calculated. The attached spreadsheets, labeled Table 3-B-3 through 3-B-18 present the calculation of the PRGs as well as the target soil concentrations for protection of human health.

References

U.S. EPA, 1989. Exposure Factors Handbook. May, 1989. EPA/600/8-89/043.

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U.S. EPA, 1991. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual Part B, Development of Risk-Based Preliminary Remediation Goals, 1991. PB9285.7-01B.

U.S. EPA, 1992. Dermal Exposure Assessment: Principles and Applications, January 1992. EPA/600/8-91/011B.

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U.S. EPA, 1996b. Soil Screening Guidance: Technical Background Document, 1996. EPA/540/R-95/128.

U.S. EPA, 1998. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual *Supplemental Guidance* Dermal Risk Assessment, Interim Guidance. NCEA-W-0364. Office of Emergency and Remedial Response, Washington, D.C.

Table 3-B-1

Summary of Exposure Values

	RME	CTE	RHE	Units	Source
All Exposure Scenarios					
Carcinogenic Target Risk	10^{-6}	10^{-6}	10^{-5}		(State of Illinois criteria)
Body Weight	70	70	70	kg	U.S. EPA, 1991
Averaging Time	70	70	70	years	U.S. EPA, 1991
Particulate Emission Factor				Calculated	exposure scenario specific
Volatilization Factor (VF)				Calculated	chemical and exposure scenario specific
Inhalation Rate (IR)	20	20	20	m^3/day	U.S. EPA, 1991
Utility Worker					
Exposure Duration (ED)	1	1	1	year	site specific
Exposure Frequency (EF)	21	8	60	days/year	site specific
Soil Ingestion Rate (IR)	480	216	200	mg/day	U.S. EPA, 1996a
Skin Surface Area (SA)	5,800	5,000	5,800	cm^2	U.S. EPA, 1996a
Soil Adherence Factor (AF)	1	0.2	0.2	mg/cm^2	U.S. EPA, 1996a
Construction Worker					
Exposure Duration (ED)	1	1	1	year	site specific
Exposure Frequency (EF)	21	10	30	days/year	site specific
Soil Ingestion Rate (IR)	480	216	200	mg/day	U.S. EPA, 1996a
Skin Surface Area (SA)	5,800	5,000	5,800	cm^2	U.S. EPA, 1996a
Soil Adherence Factor (AF)	1	0.2	0.2	mg/cm^2	U.S. EPA, 1996a
Commercial/Industrial Worker					
Exposure Duration (ED)	25	9	25	years	U.S. EPA, 1989
Exposure Frequency (EF)	165	165	97.5	days/year	site specific
Soil Ingestion Rate (IR)	50	25	2	mg/day	U.S. EPA, 1996—site specific
Skin Surface Area (SA)	5,800	5,000	840	cm^2	U.S. EPA, 1996a
Soil Adherence Factor (AF)	1.0	0.2	0.043	mg/cm^2	U.S. EPA, 1996a

Table 3B-2
Summary of Soil Risk Values
Waukegan Manufactured Gas and Coke Plant Site
(mg/kg)

Chemical	Residential		Commercial/Industrial			Utility/Construction		
	RME	CTE	RME	CTE	RHE	RME	CTE	RHE
Cancer Risk: 1X10-6								
PCBs	0.12	8.06	0.25	3	31	17	118	16.5
Arsenic	1.09	55.2	2.68	23	205	106	659	94
Benzene	1.91	41.3	3.23	10	6	580	1786	238
Benzo(a)anthracene	1.78	68.1	5.94	33	150	122	709	116
Benzo(a)pyrene	0.18	6.81	0.59	3	15	12	70.9	11.6
Benzo(b)fluranthene	1.78	68.1	5.94	33	150	122	709	116
Dibenzo(a,h)anthracene	0.18	6.81	0.59	3	15	12	70.9	11.6
Indeno(g,h,i)pyrene	1.78	68.1	5.94	33	150	122	709	116
Non-Cancer Risk: HI=1								
Dibenzofuran	653	17033	983	4955	186779	4591	40427	5390
4-Methylphenol	817	21292	1229	6194	233474	5739	50534	6738
Naphthalene	5203	141944	7704	39961	1565513	39438	369220	48556

Table 3B-3

SOIL PRG CONCENTRATIONS - RESIDENTIAL SCENARIO (RME)

PRG DRIVER: CANCER RISK

EXPOSURE MEDIA: SOIL

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral Slope Factor [1] (mg/kg-day)-1	Inhalation [1] Slope Factor (mg/kg-day)-1	Dermal Slope Factor [2] (mg/kg-day)-1	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
PCBs	7.7	1	7.7	NA	0.03	0.12
Arsenic	1.5	15	1.5	NA	0.01	1.09
Benzene	0.029	0.029	0.029	5.00E+03	0.1	1.91
Benzo(a)anthracene	0.73	NA	0.73	3.44E+07	0.13	1.78
Benzo(a)pyrene	7.3	NA	7.3	3.48E+07	0.13	0.18
Benzo(b)fluoranthene	0.73	NA	0.73	1.35E+07	0.13	1.78
Dibenzo(a,h)anthracene	7.3	NA	7.3	4.38E+08	0.13	0.18
Indeno(g,h,i)pyrene	0.73	NA	0.73	3.05E+08	0.13	1.78
Target Risk	1E-06					
EXPOSURE ASSUMPTIONS	Value	Units	Source			
IR-Ingestion Rate	100	mg/day	EPA 7/23/98			
SA-Surface Area (cm2)	5800	cm2	EPA 7/23/98			
AF-Adherence Factor (mg/cm2)	1	mg/cm2	EPA 7/23/98			
BW-Body weight (kg)	70	kg	EPA 7/23/98			
EF-Exposure frequency (days/yr)	230	days/yr	EPA 7/23/98			
ED-Exposure duration (yr)	30	yr	EPA 7/23/98			
ATC-Averaging time (days)	25550	days	EPA 7/23/98			
INHR-Inhalation rate (m3/day)	20	m3/day	EPA 7/23/98			
PEF (m3/kg)	8.600E+09	m3/kg	EPA 7/23/98			
EV (event/day)	1	event/day	EPA 7/23/98			
CF-Conversion factor (kg/mg)	1E-06	kg/mg				

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Slope Factor is assumed to equal Oral Slope Factor

[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"

[4] From: Final Technical Memorandum. EPA, 1995

PRG = (TR * ATC* BW) / [(EF * ED) * ((IR * SFo * CF) + (SA * AF * ABS * EV * SFo * CF) + (INHR * SFi * (1/ PEF+1/VF)))]

FOR PAHS: PRG = (TR * ATC* BW) / [(EF * ED) * (IR * SFo * CF) *2]

TABLE 3B-4

PRG CONCENTRATIONS - RESIDENTIAL EXPOSURE SCENARIO (RME)

PRG DRIVER: NONCANCER RISK

EXPOSURE MEDIA: Soil

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral RfD[1] mg/kg-day	Inhalation RfD[1] mg/kg-day	Dermal RfD[2] mg/kg-day	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
Dibenzofuran	0.004	NA	0.004	NA	0.1	653
4-Methylphenol	0.005	NA	0.005	1.09E+06	0.1	817
Naphthalene	0.04	NA	0.04	5.42E+04	0.13	5203

EXPOSURE ASSUMPTIONS	Value	Units	Source
IR-Ingestion Rate	100	mg/day	EPA 11/14/95
SA-Surface Area (cm2)	5800	cm2	EPA 11/14/95
AF-Adherence Factor (mg/cm2)	1	mg/cm2	EPA 11/14/95
BW-Body weight (kg)	70	kg	EPA 11/14/95
EF-Exposure frequency (days/yr)	230	days/yr	EPA 11/14/95
ED-Exposure duration (yr)	30	yr	EPA 11/14/95
ATNC (days)	10950	days	EPA 11/14/95
HI-Hazard Index (unitless)	1	unitless	EPA 11/14/95
INHR-Inhalation Rate (m3/day)	20	m3/day	EPA 11/14/95
PEF (m3/kg)	8.60E+09	m3/kg	EPA 11/14/95
EV (event/day)	1	event/day	EPA 11/14/95
CF-Conversion factor (kg/mg)	1E-06	kg/mg	

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Reference Dose is assumed to equal Oral Refernce Dose

[3] From: "Region 9: Preliminary Remediation Goals". 1998

[4] From: Final Technical Memorandum. EPA, 1995

PRG = 1 / (Oral + Inhalation + Dermal)

Oral = (IR * CF * EF * ED) / (RfDo * HI * ATNC * BW)

Inhalation = (INHR * EF * ED * (1/VF + 1/PEF)) / (RfDi * HI * ATNC * BW)

Dermal = (CF * AF * ABS * SA * EV * EF * ED) / (RfDd * HI * ATNC * BW)

Table 3B-5

SOIL PRG CONCENTRATIONS - RESIDENTIAL SCENARIO (CTE)

PRG DRIVER: CANCER RISK

EXPOSURE MEDIA: SOIL

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral Slope Factor [1] (mg/kg-day)-1	Inhalation [1] Slope Factor (mg/kg-day)-1	Dermal Slope Factor [2] (mg/kg-day)-1	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
PCBs	7.7	1	7.7	NA	0.03	8.06
Arsenic	1.5	15	1.5	NA	0.01	55.18
Benzene	0.029	0.029	0.029	5.00E+03	0.1	41.28
Benzo(a)anthracene	0.73	NA	0.73	3.44E+07	0.13	68.06
Benzo(a)pyrene	7.3	NA	7.3	3.48E+07	0.13	6.81
Benzo(b)fluoranthene	0.73	NA	0.73	1.35E+07	0.13	68.06
Dibenzo(a,h)anthracene	7.3	NA	7.3	4.38E+08	0.13	6.81
Indeno(g,h,i)pyrene	0.73	NA	0.73	3.05E+08	0.13	68.06

Target Risk	1E-06		
EXPOSURE ASSUMPTIONS	Value	Units	Source
IR-Ingestion Rate	50	mg/day	EPA 7/23/98
SA-Surface Area (cm2)	5000	cm2	EPA 7/23/98
AF-Adherence Factor (mg/cm2)	0.2	mg/cm2	EPA 7/23/98
BW-Body weight (kg)	70	kg	EPA 7/23/98
EF-Exposure frequency (days/yr)	40	days/yr	EPA 7/23/98
ED-Exposure duration (yr)	9	yr	EPA 7/23/98
ATC-Averaging time (days)	25550	days	EPA 7/23/98
INHR-Inhalation rate (m3/day)	20	m3/day	EPA 7/23/98
PEF (m3/kg)	8.600E+09	m3/kg	EPA 7/23/98
EV (event/day)	1	event/day	EPA 7/23/98
CF-Conversion factor (kg/mg)	1E-06	kg/mg	

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Slope Factor is assumed to equal Oral Slope Factor

[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"

[4] From: Final Technical Memorandum, EPA, 1995

*PRG = (TR * ATC* BW) / [(EF * ED) * ((IR * SFo * CF) + (SA * AF * ABS * EV * SFo * CF) + (INHR * SFi * (1/ PEF+1/VF))]]*

FOR PAHS: PRG = (TR * ATC* BW) / [(EF * ED) * (IR * SFo * CF) *2]

TABLE 3B-6

PRG CONCENTRATIONS - RESIDENTIAL EXPOSURE SCENARIO (CTE)

PRG DRIVER: NONCANCER RISK

EXPOSURE MEDIA: Soil

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral RfD[1] mg/kg-day	Inhalation RfD[1] mg/kg-day	Dermal RfD[2] mg/kg-day	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
Dibenzofuran	0.004	NA	0.004	NA	0.1	17033
4-Methylphenol	0.005	NA	0.005	1.09E+06	0.1	21292
Naphthalene	0.04	NA	0.04	5.42E+04	0.13	141944

EXPOSURE ASSUMPTIONS	Value	Units	Source
IR-Ingestion Rate	50	mg/day	EPA 11/14/95
SA-Surface Area (cm2)	5000	cm2	EPA 11/14/95
AF-Adherence Factor (mg/cm2)	0.2	mg/cm2	EPA 11/14/95
BW-Body weight (kg)	70	kg	EPA 11/14/95
EF-Exposure frequency (days/yr)	40	days/yr	EPA 11/14/95
ED-Exposure duration (yr)	9	yr	EPA 11/14/95
ATNC (days)	3285	days	EPA 11/14/95
HI-Hazard Index (unitless)	1	unitless	EPA 11/14/95
INHR-Inhalation Rate (m3/day)	20	m3/day	EPA 11/14/95
PEF (m3/kg)	8.60E+09	m3/kg	EPA 11/14/95
EV (event/day)	1	event/day	EPA 11/14/95
CF-Conversion factor (kg/mg)	1E-06	kg/mg	

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Reference Dose is assumed to equal Oral Refernce Dose

[3] From: "Region 9: Preliminary Remediation Goals". 1998

[4] From: Final Technical Memorandum. EPA, 1995

PRG = 1 / (Oral + Inhalation + Dermal)

Oral = (IR * CF * EF * ED) / (RfDo * HI * ATNC * BW)

Inhalation = (INHR * EF * ED * (1/VF + 1/PEF)) / (RfDi * HI * ATNC * BW)

Dermal = (CF * AF * ABS * SA * EV * EF * ED) / (RfDd * HI * ATNC * BW)

Table 3B-7

SOIL PRG CONCENTRATIONS - COMMERCIAL/INDUSTRIAL SCENARIO (RME)

PRG DRIVER: CANCER RISK

EXPOSURE MEDIA: SOIL

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral Slope Factor [1] (mg/kg-day)-1	Inhalation [1] Slope Factor (mg/kg-day)-1	Dermal Slope Factor [2] (mg/kg-day)-1	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
PCBs	7.7	1	7.7	NA	0.03	0.25
Arsenic	1.5	15	1.5	NA	0.01	2.68
Benzene	0.029	0.029	0.029	5.00E+03	0.1	3.23
Benzo(a)anthracene	0.73	NA	0.73	3.44E+07	0.13	5.94
Benzo(a)pyrene	7.3	NA	7.3	3.48E+07	0.13	0.59
Benzo(b)fluoranthene	0.73	NA	0.73	1.35E+07	0.13	5.94
Dibenzo(a,h)anthracene	7.3	NA	7.3	4.38E+08	0.13	0.59
Indeno(g,h,i)pyrene	0.73	NA	0.73	3.05E+08	0.13	5.94
Target Risk	1E-06					
EXPOSURE ASSUMPTIONS	Value	Units	Source			
IR-Ingestion Rate	50	mg/day	EPA 7/23/98			
SA-Surface Area (cm2)	5800	cm2	EPA 7/23/98			
AF-Adherence Factor (mg/cm2)	1	mg/cm2	EPA 7/23/98			
BW-Body weight (kg)	70	kg	EPA 7/23/98			
EF-Exposure frequency (days/yr)	165	days/yr	EPA 7/23/98			
ED-Exposure duration (yr)	25	yr	EPA 7/23/98			
ATC-Averaging time (days)	25550	days	EPA 7/23/98			
INHR-Inhalation rate (m3/day)	20	m3/day	EPA 7/23/98			
PEF (m3/kg)	8.600E+09	m3/kg	EPA 7/23/98			
EV (event/day)	1	event/day	EPA 7/23/98			
CF-Conversion factor (kg/mg)	1E-06	kg/mg				

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Slope Factor is assumed to equal Oral Slope Factor

[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"

[4] From: Final Technical Memorandum. EPA, 1995

PRG = (TR * ATC* BW) / [(EF * ED) * ((IR * SFo * CF) + (SA * AF * ABS * EV * SFo * CF) + (INHR * SFi * (1/ PEF+1/VF))]

FOR PAHS: PRG = (TR * ATC* BW) / [(EF * ED) * (IR * SFo * CF) *2]

TABLE 3B-8

PRG CONCENTRATIONS - COMMERCIAL/INDUSTRIAL SCENARIO (RME)

PRG DRIVER: NONCANCER RISK

EXPOSURE MEDIA: Soil

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral RfD[1] mg/kg-day	Inhalation RfD[1] mg/kg-day	Dermal RfD[2] mg/kg-day	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
Dibenzofuran	*0.004*	*NA*	*0.004*	*NA*	*0.1*	*983*
4-Methylphenol	0.005	NA	0.005	1.09E+06	0.1	1229
Naphthalene	0.04	NA	0.04	5.42E+04	0.13	7704

EXPOSURE ASSUMPTIONS	Value	Units	Source
IR-Ingestion Rate	50	mg/day	EPA 7/23/98
SA-Surface Area (cm2)	5800	cm2	EPA 7/23/98
AF-Adherence Factor (mg/cm2)	1	mg/cm2	EPA 7/23/98
BW-Body weight (kg)	70	kg	EPA 7/23/98
EF-Exposure frequency (days/yr)	165	days/yr	EPA 7/23/98
ED-Exposure duration (yr)	25	yr	EPA 7/23/98
ATNC (days)	9125	days	EPA 7/23/98
HI-Hazard Index (unitless)	1	unitless	EPA 7/23/98
INHR-Inhalation Rate (m3/day)	20	m3/day	EPA 7/23/98
PEF (m3/kg)	8.60E+09	m3/kg	EPA 7/23/98
EV (event/day)	1	event/day	EPA 7/23/98
CF-Conversion factor (kg/mg)	1E-06	kg/mg	

[1] From: *"IRIS" or "Region 9: Preliminary Remediation Goals"*

[2] Dermal Reference Dose is assumed to equal Oral Refernce Dose

[3] From: *"Region 9: Preliminary Remediation Goals". 1998*

[4] From: Final Technical Memorandum. EPA, 1995

PRG = 1 / (Oral + Inhalation + Dermal)

Oral = (IR * CF * EF * ED) / (RfDo * HI * ATNC * BW)

Inhalation = (INHR * EF * ED * (1/VF + 1/PEF)) / (RfDi * HI * ATNC * BW)

Dermal = (CF * AF * ABS * SA * EV * EF * ED) / (RfDd * HI * ATNC * BW)

Table 3B-9

SOIL PRG CONCENTRATIONS - COMMERCIAL/INDUSTIAL SCENARIO (CTE)

PRG DRIVER: CANCER RISK

EXPOSURE MEDIA: SOIL

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral Slope Factor [1] (mg/kg-day)-1	Inhalation [1] Slope Factor (mg/kg-day)-1	Dermal Slope Factor [2] (mg/kg-day)-1	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
PCBs	7.7	NA	7.7	NA	0.03	2.84
Arsenic	1.5	15	1.5	NA	0.01	22.93
Benzene	0.029	0.029	0.029	5.00E+03	0.1	10.07
Benzo(a)anthracene	0.73	NA	0.73	3.44E+07	0.13	33.00
Benzo(a)pyrene	7.3	NA	7.3	3.48E+07	0.13	3.30
Benzo(b)fluoranthene	0.73	NA	0.73	1.35E+07	0.13	33.00
Dibenzo(a,h)anthracene	7.3	NA	7.3	4.38E+08	0.13	3.30
Indeno(g,h,i)pyrene	0.73	NA	0.73	3.05E+08	0.13	33.00
Target Risk	1E-06					
EXPOSURE ASSUMPTIONS	Value	Units	Source			
IR-Ingestion Rate	25	mg/day	EPA 11/14/95			
SA-Surface Area (cm2)	5000	cm2	EPA 11/14/95			
AF-Adherence Factor (mg/cm2)	0.2	mg/cm2	EPA 11/14/95			
BW-Body weight (kg)	70	kg	EPA 11/14/95			
EF-Exposure frequency (days/yr)	165	days/yr	EPA 11/14/95			
ED-Exposure duration (yr)	9	yr	EPA 11/14/95			
ATC-Averaging time (days)	25550	days	EPA 11/14/95			
INHR-Inhalation rate (m3/day)	20	m3/day	EPA 11/14/95			
PEF (m3/kg)	8.600E+09	m3/kg	EPA 11/14/95			
EV (event/day)	1	event/day	EPA 11/14/95			
CF-Conversion factor (kg/mg)	1E-06	kg/mg				

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Slope Factor is assumed to equal Oral Slope Factor

[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"

[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"

PRG = (TR * ATC* BW) / [(EF * ED) * ((IR * SFo * CF) + (SA * AF * ABS * EV * SFo * CF) + (INHR * SFi * (1/ PEF+1/VF))]

FOR PAHS: PRG = (TR * ATC* BW) / [(EF * ED) * (IR * SFo * CF) *2]

TABLE 3B-10

PRG CONCENTRATIONS - COMMERCIAL/INDUSTRIAL EXPOSURE SCENARIO (CTE)

PRG DRIVER: NONCANCER RISK

EXPOSURE MEDIA: Soil

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral RfD[1] mg/kg-day	Inhalation RfD[1] mg/kg-day	Dermal RfD[2] mg/kg-day	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
Dibenzofuran	0.004	NA	0.004	NA	0.1	4955
4-Methylphenol	0.005	NA	0.005	1.09E+06	0.1	6194
Naphthalene	0.04	NA	0.04	5.42E+04	0.13	39961

EXPOSURE ASSUMPTIONS	Value	Units	Source
IR-Ingestion Rate	25	mg/day	EPA 11/14/95
SA-Surface Area (cm2)	5000	cm2	EPA 11/14/95
AF-Adherence Factor (mg/cm2)	0.2	mg/cm2	EPA 11/14/95
BW-Body weight (kg)	70	kg	EPA 11/14/95
EF-Exposure frequency (days/yr)	165	days/yr	EPA 11/14/95
ED-Exposure duration (yr)	9	yr	EPA 11/14/95
ATNC (days)	3285	days	EPA 11/14/95
HI-Hazard Index (unitless)	1	unitless	EPA 11/14/95
INHR-Inhalation Rate (m3/day)	20	m3/day	EPA 11/14/95
PEF (m3/kg)	8.60E+09	m3/kg	EPA 11/14/95
EV (event/day)	1	event/day	EPA 11/14/95
CF-Conversion factor (kg/mg)	1E-06	kg/mg	

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Reference Dose is assumed to equal Oral Refernce Dose

[3] From: "Region 9: Preliminary Remediation Goals". 1998

[4] From: Final Technical Memorandum. EPA, 1995

PRG = 1 / (Oral + Inhalation + Dermal)

Oral = (IR * CF * EF * ED) / (RfDo * HI * ATNC * BW)

Inhalation = (INHR * EF * ED * (1/VF + 1/PEF)) / (RfDi * HI * ATNC * BW)

Dermal = (CF * AF * ABS * SA * EV * EF * ED) / (RfDd * HI * ATNC * BW)

Table 3B-11

SOIL TSC CONCENTRATIONS - COMMERCIAL/INDUSTRIAL SCENARIO (RHE)

TSC DRIVER: CANCER RISK

EXPOSURE MEDIA: SOIL

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral Slope Factor [1] (mg/kg-day)-1	Inhalation [1] Slope Factor (mg/kg-day)-1	Dermal Slope Factor [2] (mg/kg-day)-1	VF[4] m3/kg	ABS[3] Factor	TSC mg/kg
PCBs	7.7	NA	7.7	NA	0.03	30.90
Arsenic	1.5	15	1.5	NA	0.01	205.15
Benzene	0.029	0.029	0.029	5.00E+03	0.1	6.32
Benzo(a)anthracene	0.73	NA	0.73	3.44E+07	0.13	150.12
Benzo(a)pyrene	7.3	NA	7.3	3.48E+07	0.13	15.01
Benzo(b)fluoranthene	0.73	NA	0.73	1.35E+07	0.13	150.12
Dibenzo(a,h)anthracene	7.3	NA	7.3	4.38E+08	0.13	15.01
Indeno(g,h,i)pyrene	0.73	NA	0.73	3.05E+08	0.13	150.12
Target Risk	1E-06					
EXPOSURE ASSUMPTIONS	Value	Units	Source			
IR-Ingestion Rate	2	mg/day	Site specific			
SA-Surface Area (cm2)	840	cm2	EPA 1996			
AF-Adherence Factor (mg/cm2)	0.043	mg/cm2	EPA 1996			
BW-Body weight (kg)	70	kg	EPA 1996			
EF-Exposure frequency (days/yr)	97.5	days/yr	Site sspecific			
ED-Exposure duration (yr)	25	yr	EPA 1996			
ATC-Averaging time (days)	25550	days	EPA 1996			
INHR-Inhalation rate (m3/day)	20	m3/day	EPA 1996			
PEF (m3/kg)	8.600E+09	m3/kg	EPA 11/14/95			
EV (event/day)	1	event/day	EPA 11/14/95			
CF-Conversion factor (kg/mg)	1E-06	kg/mg				

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Slope Factor is assumed to equal Oral Slope Factor

[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"

[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"

PRG = (TR * ATC* BW) / [(EF * ED) * ((IR * SFo * CF) + (SA * AF * ABS * EV * SFo * CF) + (INHR * SFI * (1/ PEF+1/VF)))]

TABLE 3B-12

TSC CONCENTRATIONS - COMMERCIAL/INDUSTRIAL EXPOSURE SCENARIO (RHE)

TSC DRIVER: NONCANCER RISK

EXPOSURE MEDIA: Soil

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral RfD[1] mg/kg-day	Inhalation RfD[1] mg/kg-day	Dermal RfD[2] mg/kg-day	VF[4] m3/kg	ABS[3] Factor	TSC mg/kg
Dibenzofuran	0.004	NA	0.004	NA	0.1	186779
4-Methylphenol	0.005	NA	0.005	1.09E+06	0.1	233474
Naphthalene	0.04	NA	0.04	5.42E+04	0.13	1565513

EXPOSURE ASSUMPTIONS	Value	Units	Source
IR-Ingestion Rate	2	mg/day	Site specific
SA-Surface Area (cm2)	840	cm2	Site specific
AF-Adherence Factor (mg/cm2)	0.043	mg/cm2	EPA 1996
BW-Body weight (kg)	70	kg	EPA 1996
EF-Exposure frequency (days/yr)	97.5	days/yr	Site specific
ED-Exposure duration (yr)	25	yr	EPA 1996
ATNC (days)	9125	days	EPA 1996
HI-Hazard Index (unitless)	1	unitless	EPA 1989
INHR-Inhalation Rate (m3/day)	20	m3/day	EPA 1996
PEF (m3/kg)	8.60E+09	m3/kg	EPA 7/23/98
EV (event/day)	1	event/day	Site specific
CF-Conversion factor (kg/mg)	1E-06	kg/mg	

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Reference Dose is assumed to equal Oral Refernce Dose

[3] From: "Region 9: Preliminary Remediation Goals". 1998

[4] From: Final Technical Memorandum. EPA, 1995

PRG = 1 / (Oral + Inhalation + Dermal)

Oral = (IR * CF * EF * ED) / (RfDo * HI * ATNC * BW)

Inhalation = (INHR * EF * ED * (1/VF + 1/PEF)) / (RfDi * HI * ATNC * BW)

Dermal = (CF * AF * ABS * SA * EV * EF * ED) / (RfDd * HI * ATNC * BW)

Table 3B-13

SOIL PRG CONCENTRATIONS - UTILITY WORKER SCENARIO (RME)

PRG DRIVER: CANCER RISK

EXPOSURE MEDIA: SOIL

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral Slope Factor [1] (mg/kg-day)-1	Inhalation [1] Slope Factor (mg/kg-day)-1	Dermal Slope Factor [2] (mg/kg-day)-1	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
PCBs	7.7	NA	7.7	NA	0.03	16.91
Arsenic	1.5	15	1.5	NA	0.01	105.53
Benzene	0.029	0.029	0.029	5.00E+03	0.1	580.39
Benzo(a)anthracene	0.73	NA	0.73	3.44E+07	0.13	121.53
Benzo(a)pyrene	7.3	NA	7.3	3.48E+07	0.13	12.15
Benzo(b)fluoranthene	0.73	NA	0.73	1.35E+07	0.13	121.53
Dibenzo(a,h)anthracene	7.3	NA	7.3	4.38E+08	0.13	12.15
Indeno(g,h,i)pyrene	0.73	NA	0.73	3.05E+08	0.13	121.53
Target Risk	1E-06					

EXPOSURE ASSUMPTIONS	Value	Units	Source
IR-Ingestion Rate	480	mg/day	EPA 7/23/98
SA-Surface Area (cm2)	5800	cm2	EPA 7/23/98
AF-Adherence Factor (mg/cm2)	1	mg/cm2	EPA 7/23/98
BW-Body weight (kg)	70	kg	EPA 7/23/98
EF-Exposure frequency (days/yr)	21	days/yr	EPA 7/23/98
ED-Exposure duration (yr)	1	yr	EPA 7/23/98
ATC-Averaging time (days)	25550	days	EPA 7/23/98
INHR-Inhalation rate (m3/day)	20	m3/day	EPA 7/23/98
PEF (m3/kg)	4.300E+09	m3/kg	EPA 7/23/98
EV (event/day)	1	event/day	EPA 7/23/98
CF-Conversion factor (kg/mg)	1E-06	kg/mg	

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Slope Factor is assumed to equal Oral Slope Factor

[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"

[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"

PRG = (TR * ATC* BW) / [(EF * ED) * ((IR * SFo * CF) + (SA * AF * ABS * EV * SFo * CF) + (INHR * SFi * (1/ PEF+1/VF))]

FOR PAHS: PRG = (TR * ATC* BW) / [(EF * ED) * (IR * SFo * CF) *2]

TABLE 3B-14

PRG CONCENTRATIONS - UTILITY WORKER (RME)

PRG DRIVER: NONCANCER RISK

EXPOSURE MEDIA: Soil

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral RfD[1] mg/kg-day	Inhalation RfD[1] mg/kg-day	Dermal RfD[2] mg/kg-day	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
Dibenzofuran	0.004	NA	0.004	NA	0.1	4591
4-Methylphenol	0.005	NA	0.005	1.09E+06	0.1	5739
Naphthalene	0.04	NA	0.04	5.42E+04	0.13	39438

EXPOSURE ASSUMPTIONS	Value	Units	Source
IR-Ingestion Rate	480	mg/day	EPA 7/23/98
SA-Surface Area (cm2)	5800	cm2	EPA 7/23/98
AF-Adherence Factor (mg/cm2)	1	mg/cm2	EPA 7/23/98
BW-Body weight (kg)	70	kg	EPA 7/23/98
EF-Exposure frequency (days/yr)	21	days/yr	EPA 7/23/98
ED-Exposure duration (yr)	1	yr	EPA 7/23/98
ATNC (days)	365	days	EPA 7/23/98
HI-Hazard Index (unitless)	1	unitless	EPA 7/23/98
INHR-Inhalation Rate (m3/day)	20	m3/day	EPA 7/23/98
PEF (m3/kg)	4.30E+09	m3/kg	EPA 7/23/98
EV (event/day)	1	event/day	EPA 7/23/98
CF-Conversion factor (kg/mg)	1E-06	kg/mg	

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Reference Dose is assumed to equal Oral Refernce Dose

[3] From: "Region 9: Preliminary Remediation Goals". 1998

[4] From: Final Technical Memorandum. EPA, 1995

PRG = 1 / (Oral + Inhalation + Dermal)

Oral = (IR * CF * EF * ED) / (RfDo * HI * ATNC * BW)

Inhalation = (INHR * EF * ED * (1/VF + 1/PEF)) / (RfDi * HI * ATNC * BW)

Dermal = (CF * AF * ABS * SA * EV * EF * ED) / (RfDd * HI * ATNC * BW)

Table 3B-15

SOIL PRG CONCENTRATIONS - UTILITY WORKER SCENARIO (CTE)

PRG DRIVER: CANCER RISK

EXPOSURE MEDIA: SOIL

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral Slope Factor [1] (mg/kg-day)-1	Inhalation [1] Slope Factor (mg/kg-day)-1	Dermal Slope Factor [2] (mg/kg-day)-1	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
PCBs	7.7	NA	7.7	NA	0.03	118.02
Arsenic	1.5	15	1.5	NA	0.01	659.34
Benzene	0.029	0.029	0.029	5.00E+03	0.1	1786.15
Benzo(a)anthracene	0.73	NA	0.73	3.44E+07	0.13	708.91
Benzo(a)pyrene	7.3	NA	7.3	3.48E+07	0.13	70.89
Benzo(b)fluoranthene	0.73	NA	0.73	1.35E+07	0.13	708.91
Dibenzo(a,h)anthracene	7.3	NA	7.3	4.38E+08	0.13	70.89
Indeno(g,h,i)pyrene	0.73	NA	0.73	3.05E+08	0.13	708.91
Target Risk	1E-06					

EXPOSURE ASSUMPTIONS	Value	Units	Source
IR-Ingestion Rate	216	mg/day	EPA 11/14/95
SA-Surface Area (cm2)	5000	cm2	EPA 11/14/95
AF-Adherence Factor (mg/cm2)	0.2	mg/cm2	EPA 11/14/95
BW-Body weight (kg)	70	kg	EPA 11/14/95
EF-Exposure frequency (days/yr)	8	days/yr	EPA 11/14/95
ED-Exposure duration (yr)	1	yr	EPA 11/14/95
ATC-Averaging time (days)	25550	days	EPA 11/14/95
INHR-Inhalation rate (m3/day)	20	m3/day	EPA 11/14/95
PEF (m3/kg)	4.300E+09	m3/kg	EPA 11/14/95
EV (event/day)	1	event/day	EPA 11/14/95
CF-Conversion factor (kg/mg)	1E-06	kg/mg	

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Slope Factor is assumed to equal Oral Slope Factor

[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"

[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"

*PRG = (TR * ATC* BW) / [(EF * ED) * ((IR * SFo * CF) + (SA * AF * ABS * EV * SFo * CF) + (INHR * SFi * (1/ PEF+1/VF)))]*

FOR PAHS: PRG = (TR * ATC* BW) / [(EF * ED) * (IR * SFo * CF) *2]

TABLE 3B-16
PRG CONCENTRATIONS - UTILITY WORKER (CTE)
PRG DRIVER: NONCANCER RISK
EXPOSURE MEDIA: Soil
ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral RfD[1] mg/kg-day	Inhalation RfD[1] mg/kg-day	Dermal RfD[2] mg/kg-day	VF[4] m3/kg	ABS[3] Factor	PRG mg/kg
Dibenzofuran	0.004	NA	0.004	NA	0.1	40427
4-Methylphenol	0.005	NA	0.005	1.09E+06	0.1	50534
Naphthalene	0.04	NA	0.04	5.42E+04	0.13	369220
EXPOSURE ASSUMPTIONS	Value	Units	Source			
IR-Ingestion Rate	216	mg/day	EPA 11/14/95			
SA-Surface Area (cm2)	5000	cm2	EPA 11/14/95			
AF-Adherence Factor (mg/cm2)	0.2	mg/cm2	EPA 11/14/95			
BW-Body weight (kg)	70	kg	EPA 11/14/95			
EF-Exposure frequency (days/yr)	8	days/yr	EPA 11/14/95			
ED-Exposure duration (yr)	1	yr	EPA 11/14/95			
ATNC (days)	365	days	EPA 11/14/95			
HI-Hazard Index (unitless)	1	unitless	EPA 11/14/95			
INHR-Inhalation Rate (m3/day)	20	m3/day	EPA 11/14/95			
PEF (m3/kg)	4.30E+09	m3/kg	EPA 11/14/95			
EV (event/day)	1	event/day	EPA 11/14/95			
CF-Conversion factor (kg/mg)	1E-06	kg/mg				

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"
[2] Dermal Reference Dose is assumed to equal Oral Refernce Dose
[3] From: "Region 9: Preliminary Remediation Goals". 1998
[4] From: Final Technical Memorandum. EPA, 1995

PRG = 1 / (Oral + Inhalation + Dermal)
Oral = (IR * CF * EF * ED) / (RfDo * HI * ATNC * BW)
Inhalation = (INHR * EF * ED * (1/VF + 1/PEF)) / (RfDi * HI * ATNC * BW)
Dermal = (CF * AF * ABS * SA * EV * EF * ED) / (RfDd * HI * ATNC * BW)

Table 3B-17
SOIL TSC CONCENTRATIONS - UTILITY WORKER SCENARIO (RHE)
TSC DRIVER: CANCER RISK
EXPOSURE MEDIA: SOIL
ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral Slope Factor [1] (mg/kg-day)-1	Inhalation [1] Slope Factor (mg/kg-day)-1	Dermal Slope Factor [2] (mg/kg-day)-1	VF[4] m3/kg	ABS[3] Factor	TSC mg/kg
PCBs	7.7	1	7.7	NA	0.03	16.49
Arsenic	1.5	15	1.5	NA	0.01	93.89
Benzene	0.029	0.029	0.029	5.00E+03	0.1	238.15
Benzo(a)anthracene	0.73	NA	0.73	3.44E+07	0.13	116.40
Benzo(a)pyrene	7.3	NA	7.3	3.48E+07	0.13	11.64
Benzo(b)fluoranthene	0.73	NA	0.73	1.35E+07	0.13	116.40
Dibenzo(a,h)anthracene	7.3	NA	7.3	4.38E+08	0.13	11.64
Indeno(g,h,i)pyrene	0.73	NA	0.73	3.05E+08	0.13	116.40

Target Risk	1E-06		
EXPOSURE ASSUMPTIONS	Value	Units	Source
IR-Ingestion Rate	200	mg/day	EPA 11/14/95
SA-Surface Area (cm2)	5800	cm2	EPA 11/14/95
AF-Adherence Factor (mg/cm2)	0.2	mg/cm2	EPA 11/14/95
BW-Body weight (kg)	70	kg	EPA 11/14/95
EF-Exposure frequency (days/yr)	60	days/yr	Site specific
ED-Exposure duration (yr)	1	yr	Site specific
ATC-Averaging time (days)	25550	days	EPA 11/14/95
INHR-Inhalation rate (m3/day)	20	m3/day	EPA 11/14/95
PEF (m3/kg)	4.300E+09	m3/kg	EPA 11/14/95
EV (event/day)	1	event/day	EPA 11/14/95
CF-Conversion factor (kg/mg)	1E-06	kg/mg	

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"
[2] Dermal Slope Factor is assumed to equal Oral Slope Factor
[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"
[3] From: "EPA 7/23/98" and "Region 9: Preliminary Remediation Goals"
PRG = (TR * ATC* BW) / [(EF * ED) * ((IR * SFo * CF) + (SA * AF * ABS * EV * SFo * CF) + (INHR * SFi * (1/ PEF+1/VF)))]

TABLE 3B-18

TSC CONCENTRATIONS - UTILITY WORKER (RHE)

TSC DRIVER: NONCANCER RISK

EXPOSURE MEDIA: Soil

ROUTE OF EXPOSURE: DERMAL ABSORPTION, INGESTION AND INHALATION

Chemical	Oral RfD[1] mg/kg-day	Inhalation RfD[1] mg/kg-day	Dermal RfD[2] mg/kg-day	VF[4] m3/kg	ABS[3] Factor	TSC mg/kg
Dibenzofuran	0.004	NA	0.004	NA	0.1	5390
4-Methylphenol	0.005	NA	0.005	1.09E+06	0.1	6738
Naphthalene	0.04	NA	0.04	5.42E+04	0.13	48556

EXPOSURE ASSUMPTIONS	Value	Units	Source
IR-Ingestion Rate	200	mg/day	EPA 11/14/95
SA-Surface Area (cm2)	5800	cm2	EPA 11/14/95
AF-Adherence Factor (mg/cm2)	0.2	mg/cm2	EPA 11/14/95
BW-Body weight (kg)	70	kg	EPA 11/14/95
EF-Exposure frequency (days/yr)	60	days/yr	Site specific
ED-Exposure duration (yr)	1	yr	Site specific
ATNC (days)	365	days	Site specific
HI-Hazard Index (unitless)	1	unitless	EPA 1989
INHR-Inhalation Rate (m3/day)	20	m3/day	EPA 11/14/95
PEF (m3/kg)	*4.30E+09*	m3/kg	*EPA 11/14/95*
EV (event/day)	1	event/day	EPA 11/14/95
CF-Conversion factor (kg/mg)	1E-06	kg/mg	

[1] From: "IRIS" or "Region 9: Preliminary Remediation Goals"

[2] Dermal Reference Dose is assumed to equal Oral Refernce Dose

[3] From: "Region 9: Preliminary Remediation Goals". 1998

[4] From: Final Technical Memorandum. EPA, 1995

PRG = 1 / (Oral + Inhalation + Dermal)

Oral = (IR * CF * EF * ED) / (RfDo * HI * ATNC * BW)

Inhalation = (INHR * EF * ED * (1/VF + 1/PEF)) / (RfDi * HI * ATNC * BW)

Dermal = (CF * AF * ABS * SA * EV * EF * ED) / (RfDd * HI * ATNC * BW)

Appendix B
Soil Screening Guidance Models
and
Vapor Intrusion Models

Appendix B

Commercial/Industrial Worker Scenario

New RHE exposure values, consistent with the practices adopted for the other RHE scenarios, were developed for the commercial/industrial vapor intrusion scenario. The two factors to develop for this exposure scenario are the exposure duration and the exposure frequency. The median occupational tenure (both sexes, all occupations) is 6.6 years (U.S. EPA, 1997; Table 15-176). Nine years would reasonably represent an RHE scenario exposure duration. However, in order to maintain consistency with the outdoor commercial/industrial scenario which is part of the basis for the ROD cleanup levels, 25-year duration has been selected for this scenario.

An RHE exposure frequency was developed based on work week statistics. The weighted mean hours per week worked (both sexes) is 21.82 hours (U.S. EPA, 1997; Table 15A-6). An exposure frequency of 219 days per year reflects 35 hours per week worked over a 50 week period (assuming 2 weeks vacation). This occupational exposure frequency, 219 days per year (U.S. EPA, 1993), was selected for the RHE. From a practical standpoint, this is a high exposure for workers, as it assumes they are on the ground floor of the building and spend very little working time elsewhere (e.g., out of the office for meetings or other responsibilities, in other buildings, or even on other floors of the same building).

Soil Screening Guidance for Chemicals -
Model Calculation Output

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Soil Screening Guidance for Chemicals

Equation Values for Inhalation of Volatiles

Volatilization Factor Parameter	Value	Soil Saturation Concentration Parameter	Value	Noncarcinogenic Parameter	Value	Carcinogenic Parameter	Value
Surface Area (acres)	0.5			Target Hazard Quotient (unitless)	1	Target Risk (unitless)	1.0E-6
City (climate zone)	Chicago (VII)			Exposure Duration (yr)	6	Exposure Duration (yr)	6
Q/C (g/m^2-s per kg/m^3)	97.78			Exposure Frequency (day/yr)	20	Exposure Frequency (day/yr)	20
Fraction organic carbon (unitless)	0.02	Fraction organic carbon (unitless)	0.02			Average Lifetime (yr)	70
Dry soil bulk density (g/cm^3)	1.67	Dry soil bulk density (g/cm^3)	1.67				
Soil particle density (g/cm^3)	2.74	Soil particle density (g/cm^3)	2.74				
Water-filled soil porosity (L_{water}/L_{soil})	0.26	Water-filled soil porosity (L_{water}/L_{soil})	0.26				
Exposure interval (s)	9.5e08						

Soil Screening Levels for Inhalation of Volatiles (mg/kg)

Analyte	Cas Number	Inhalation RfC	Inhalation Unit Risk	Volatilization Factor	Soil Saturation Concentration	Noncarcinogenic	Carcinogenic
Aroclor 1254	11097691		5.7E-04 [u]	4.2E+06	2.3E+02		1.6E+03

Arsenic, Inorganic	7440382		4.3E-03 [a]				
Benzene	71432	3.0E-02 [a]	7.8E-06 [a]	2.0E+04	2.4E+03	1.1E+04	5.4E+02
Benzo[a]pyrene	50328			3.6E+07			
Cresol, p-	106445			3.2E+05	3.8E+04		
Dibenzofuran	132649				6.9E+02		
Naphthalene	91203	3.0E-03 [a]		4.3E+05		2.4E+04	

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Soil Screening Guidance for Chemicals

Equation Values for Ingestion

Noncarcinogenic Parameter	Value	Carcinogenic Age-adjusted Parameter	Value	Carcinogenic Nonadjusted Parameter	Value
Target Hazard Quotient (unitless)	1	Target Risk (unitless)	1.0E-5	Target Risk (unitless)	1.0E-5
Body Weight (kg)	70	Adult Body Weight (kg)	70	Body Weight (kg)	70
		Child Body Weight (kg)	0		
Exposure Duration (yr)	25	Adult Exposure Duration (yr)	25	Exposure Duration (yr)	25
		Child Exposure Duration (yr)	0		
Exposure Frequency (day/yr)	97.5	Exposure Frequency (day/yr)	97.5	Exposure Frequency (day/yr)	97.5
Intake Rate (mg/day)	2	Adult Intake Rate (mg/day)	2	Intake Rate (mg/day)	2
		Child Intake Rate (mg/day)	0		
		Average Lifetime (yr)	70	Average Lifetime (yr)	70
		Age-adjusted Ingestion Factor (mg-yr/kg-day)			

Soil Screening Levels for Ingestion (mg/kg)

Analyte	Cas Number	Oral RfD	Oral Slope Factor	Noncarcinogenic	Carcinogenic (Age-adjusted)	Carcinogenic (Nonadjusted)
Aroclor 1254	11097691	2.00E-05 [a]	2.00E+00 [a]	2.62E+03		1.83E+03
Arsenic, Inorganic	7440382	3.00E-04 [a]	1.50E+00 [a]	3.93E+04		2.45E+03
Benzene	71432	4.00E-03	5.50E-02 [a]	5.24E+05		6.67E+04
Benzo[a]pyrene	50328					5.03E+02

		7.30E+00 [a]	
Cresol, p-	106445	5.00E-03 [b]	6.55E+05
Dibenzofuran	132649	4.00E-03	5.24E+05
Naphthalene	91203	2.00E-02 [a]	2.62E+06

Equation Values for Inhalation of Fugitive Dust

Particulate Emission Factor Parameter	Value	Noncarcinogenic Parameter	Value	Carcinogenic Parameter	Value
Surface Area (acres)	0.5	Target Hazard Quotient (unitless)	1	Target Risk (unitless)	1.0E-5
City (climate zone)	Chicago(VII)	Exposure Duration (yr)	25	Exposure Duration (yr)	25
Q/C (g/m^2-s per kg/m^3)	97.78	Exposure Frequency (day/yr)	97.5	Exposure Frequency (day/yr)	97.5
Fraction of vegetative cover (unitless)	0.5			Average Lifetime (yr)	70
Mean annual windspeed (m/s)	4.65				
Equivalent threshold value of windspeed at 7m (m/s)	11.32				
Function dependent on U_m/U_t (unitless)	0.182				

Soil Screening Levels for Inhalation of Fugitive Dust (mg/kg)

Analyte	Cas Number	Inhalation RfC	Inhalation Unit Risk	Particulate Emission Factor	Noncarcinogenic	Carcinogenic
Aroclor 1254	11097691		5.7E-04 [u]	1.55E+09		2.84E+05
Arsenic, Inorganic	7440382		4.3E-03 [a]	1.55E+09		3.78E+04
Benzene	71432	3.00E-02 [a]	7.8E-06 [a]	1.55E+09	1.74E+08	2.08E+07
Benzo[a]pyrene	50328			1.55E+09		
Cresol, p-	106445			1.55E+09		
Dibenzofuran	132649			1.55E+09		
Naphthalene	91203	3.00E-03 [a]		1.55E+09	1.74E+07	

Equation Values for Inhalation of Volatiles

Volatilization Factor Parameter	Value	Soil Saturation Concentration Parameter	Value	Noncarcinogenic Parameter	Value	Carcinogenic Parameter	Value
Surface Area (acres)	0.5			Target Hazard Quotient (unitless)	1	Target Risk (unitless)	1.0E-5
City (climate zone)	Chicago (VII)			Exposure Duration (yr)	25	Exposure Duration (yr)	25
Q/C (g/m^2-s per kg/m^3)	97.78			Exposure Frequency (day/yr)	97.5	Exposure Frequency (day/yr)	97.5
Fraction organic carbon (unitless)	0.02	Fraction organic carbon (unitless)	0.02			Average Lifetime (yr)	70
Dry soil bulk density (g/cm^3)	1.67	Dry soil bulk density (g/cm^3)	1.67				
Soil particle density (g/cm^3)	2.74	Soil particle density (g/cm^3)	2.74				
Water-filled soil porosity (L_{water}/L_{soil})	0.26	Water-filled soil porosity (L_{water}/L_{soil})	0.26				
Exposure interval (s)	9.5e08						

Soil Screening Levels for Inhalation of Volatiles (mg/kg)

Analyte	Cas Number	Inhalation RfC	Inhalation Unit Risk	Volatilization Factor	Soil Saturation Concentration	Noncarcinogenic	Carcinogenic
Aroclor 1254	11097691		5.7E-04 [u]	4.2E+06	2.3E+02		7.6E+02
Arsenic, Inorganic	7440382		4.3E-03 [a]				
Benzene	71432	3.0E-02 [a]	7.8E-06 [a]	2.0E+04	2.4E+03	2.2E+03	2.6E+02
Benzo[a]pyrene	50328			3.6E+07			
Cresol, p-	106445			3.2E+05	3.8E+04		
Dibenzofuran	132649				6.9E+02		
Naphthalene	91203	3.0E-03 [a]		4.3E+05		4.9E+03	

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Equation Values for Ingestion

Noncarcinogenic Parameter	Value	Carcinogenic Age-adjusted Parameter	Value	Carcinogenic Nonadjusted Parameter	Value
Target Hazard Quotient (unitless)	1	Target Risk (unitless)	1.0E-5	Target Risk (unitless)	1.0E-5
Body Weight (kg)	70	Adult Body Weight (kg)	70	Body Weight (kg)	70
		Child Body Weight (kg)	0		
Exposure Duration (yr)	1	Adult Exposure Duration (yr)	1	Exposure Duration (yr)	1
		Child Exposure Duration (yr)	0		
Exposure Frequency (day/yr)	60	Exposure Frequency (day/yr)	60	Exposure Frequency (day/yr)	60
Intake Rate (mg/day)	200	Adult Intake Rate (mg/day)	200	Intake Rate (mg/day)	200
		Child Intake Rate (mg/day)	0		
		Average Lifetime (yr)	70	Average Lifetime (yr)	70
		Age-adjusted Ingestion Factor (mg-yr/kg-day)			

Soil Screening Levels for Ingestion (mg/kg)

Analyte	Cas Number	Oral RfD	Oral Slope Factor	Noncarcinogenic	Carcinogenic (Age-adjusted)	Carcinogenic (Nonadjusted)
Aroclor 1254	11097691	2.00E-05 [a]	2.00E+00 [n]	4.26E+01		7.45E+02
Arsenic, Inorganic	7440382	3.00E-04 [a]	1.50E+00 [a]	6.39E+02		9.94E+02
Benzene	71432	4.00E-03	5.50E-02 [a]	8.52E+03		2.71E+04
Benzo[a]pyrene	50328					2.04E+02

			7.30E+00 [a]	
Cresol, p-	106445	5.00E-03 [b]		1.06E+04
Dibenzofuran	132649	4.00E-03		8.52E+03
Naphthalene	91203	2.00E-02 [a]		4.26E+04

Equation Values for Inhalation of Fugitive Dust

Particulate Emission Factor Parameter	Value	Noncarcinogenic Parameter	Value	Carcinogenic Parameter	Value
Surface Area (acres)	0.5	Target Hazard Quotient (unitless)	1	Target Risk (unitless)	1.0E-5
City (climate zone)	Chicago(VII)	Exposure Duration (yr)	1	Exposure Duration (yr)	1
Q/C (g/m^2-s per kg/m^3)	97.78	Exposure Frequency (day/yr)	60	Exposure Frequency (day/yr)	60
Fraction of vegetative cover (unitless)	0.5			Average Lifetime (yr)	70
Mean annual windspeed (m/s)	4.65				
Equivalent threshold value of windspeed at 7m (m/s)	11.32				
Function dependent on U_m/U_t (unitless)	0.182				

Soil Screening Levels for Inhalation of Fugitive Dust (mg/kg)

Analyte	Cas Number	Inhalation RfC	Inhalation Unit Risk	Particulate Emission Factor	Noncarcinogenic	Carcinogenic
Aroclor 1254	11097691		5.7E-04 [u]	1.55E+09		1.16E+07
Arsenic, Inorganic	7440382		4.3E-03 [a]	1.55E+09		1.54E+06
Benzene	71432	3.00E-02 [a]	7.8E-06 [a]	1.55E+09	2.83E+08	8.46E+08
Benzo[a]pyrene	50328			1.55E+09		
Cresol, p-	106445			1.55E+09		
Dibenzofuran	132649			1.55E+09		
Naphthalene	91203	3.00E-03 [a]		1.55E+09	2.83E+07	

Equation Values for Inhalation of Volatiles

Volatilization Factor Parameter	Value	Soil Saturation Concentration Parameter	Value	Noncarcinogenic Parameter	Value	Carcinogenic Parameter	Value
Surface Area (acres)	0.5			Target Hazard Quotient (unitless)	1	Target Risk (unitless)	1.0E-5
City (climate zone)	Chicago (VII)			Exposure Duration (yr)	1	Exposure Duration (yr)	1
Q/C (g/m^2-s per kg/m^3)	97.78			Exposure Frequency (day/yr)	60	Exposure Frequency (day/yr)	60
Fraction organic carbon (unitless)	0.02	Fraction organic carbon (unitless)	0.02			Average Lifetime (yr)	70
Dry soil bulk density (g/cm^3)	1.67	Dry soil bulk density (g/cm^3)	1.67				
Soil particle density (g/cm^3)	2.74	Soil particle density (g/cm^3)	2.74				
Water-filled soil porosity (L_{water}/L_{soil})	0.26	Water-filled soil porosity (L_{water}/L_{soil})	0.26				
Exposure interval (s)	9.5e08						

Soil Screening Levels for Inhalation of Volatiles (mg/kg)

Analyte	Cas Number	Inhalation RfC	Inhalation Unit Risk	Volatilization Factor	Soil Saturation Concentration	Noncarcinogenic	Carcinogenic
Aroclor 1254	11097691		5.7E-04 [u]	4.2E+06	2.3E+02		3.1E+04
Arsenic, Inorganic	7440382		4.3E-03 [a]				
Benzene	71432	3.0E-02 [a]	7.8E-06 [a]	2.0E+04	2.4E+03	3.6E+03	1.1E+04
Benzo[a]pyrene	50328			3.6E+07			
Cresol, p-	106445			3.2E+05	3.8E+04		
Dibenzofuran	132649				6.9E+02		
Naphthalene	91203	3.0E-03 [a]		4.3E+05		7.9E+03	

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